



PROGRAMMABLE AC POWER SOURCE

61701/61702/61703/61704

User's Manual

Edition
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P/N A11000747

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CE-Conformity Declaration

For the following equipment :

Product Name : Programmable AC Source

Model Name : 61701 / 61702 / 61703 / 61704

Manufacturer's Name : Chroma ATE Inc.

Manufacturer's Address : 43 Wu-Chuan Road, Wu-Ku Industrial Park, Wu-Ku,
Taipei Hsien, Taiwan, R.O.C.

is herewith confirmed to comply with the requirements set out in the Council Directive on the Approximation of the Laws of the Member States Relating to Electromagnetic Compatibility (89/336/EEC) and electrical equipment designed for use within certain voltage limits(73/23/EEC ; 93/68/EEC)

For electromagnetic compatibility, the following standard were applied :

EMC :	EN 61326 : 1997 Class A + Amd 1 : 1998	
	IEC 1000-4-2 : 1995	Electrostatic Discharge
	IEC 1000-4-3 : 1995	Radio-Frequency Electromagnetic Field
	IEC 1000-4-4 : 1995	Fast Transient Burst
	IEC 1000-4-5 : 1995	Surge Immunity test
	IEC 1000-4-6 : 1996	Immunity To Conducted Disturbances, Induced By Radio Frequency Fields
	IEC 1000-4-11 : 1994	Voltage Dips, Short Interruptions and Voltage Variations Immunity Test
	EN 61000-3-2: 1995 Class A + Amd 1 : 1998 + Amd 2 : 1998	Harmonics current
	EN 61000-3-3 : 1995	Voltage Fluctuations

For safety requirement, the following standard was applied :

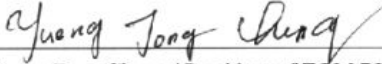
Safety : EN 61010-1 : (1993)+A2(1995)

Taiwan

October, 2002

Place

Date


Yueng Tong Cheng / President of T&M BU

Warning :

This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or specific WARNINGS given elsewhere in this manual will violate safety standards of design, manufacture, and intended use of the instrument.

Chroma assumes no liability for the customer's failure to comply with these requirements.

BEFORE APPLYING POWER

Verify that the product is set to match with the line voltage.

PROTECTIVE GROUNDING

Make sure to connect the protective grounding to prevent an electric shock before turning on the power.

NECESSITY OF PROTECTIVE GROUNDING

Never cut off the internal or external protective grounding wire, or disconnect the wiring of protective grounding terminal. Doing so will cause a potential shock hazard that may bring injury to a person.

FUSES

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) can be used. Do not use different fuses or short-circuited fuseholders. To do so might cause a shock or fire hazard.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes.

DO NOT REMOVE THE COVER OF THE INSTRUMENT

Operating personnel must not remove the cover of the instrument. Only qualified service personnel can do component replacement and internal adjustment.

WARNING	<i>LETHAL VOLTAGES.</i> Ac sources can supply 426 V peak at their output. DEATH on contact may result if the output terminals or circuits connected to the output are touched when power is applied.
----------------	---

SAFETY SYMBOLS

	DANGER – High voltage.
	Explanation: To avoid injury, death of personnel, or damage to the instrument, the operator must refer to an explanation in the instruction manual.
	Protective grounding terminal: To protect against electrical shock in case of a fault. This symbol indicates that the terminal must be connected to ground before operation of equipment.
WARNING	A WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like which may result in injury or death of personnel if it is not rightly observed.

ACOUSTIC NOISE INFORMATION

This product has a sound pressure emission (at the operator's side) < 65dB(A).

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1. General Information

1.1 Introduction

The series of Chroma AC source 61701/61702/61703/61704 are high efficiency, 3-phase AC power source which provide sine wave output with low distortion, and accurate measurement of power. The DSP microprocessor generates accurate, stable output voltage and frequency. The PWM design of power stage allows for full volt-ampere into loads. The front panel has both RPG (rotary pulse generator) and keypad controls for setting the output voltage and frequency. The LCD provides a complete operating state of the unit to the user. Remote programming is accomplished either through the GPIB bus or the RS-232C serial port.

1.2 Key Features

A. Configuration

- Local operation from the keypad on the front panel.
- Remote operation via GPIB or RS-232C interface.
- Protection against Over-power, Over-Current, Over-temperature, Fan-fail.
- Temperature-controlled fan speed.
- Built-in output isolation relays.

B. Input/Output

- Selective output voltage with full scale of 150V/300V.
- Universal of input voltage range 61701/61702: 90 ~ 250Vac, 61703/61704: 190 ~ 250Vac.
- Measurement of V, I, P, CF, and PF.
- Remotely inhibited control.
- AC ON/OFF output signal.

1.3 Specifications

The operation specifications of the model 61701/61702/61703/61704 are listed below (on the next page). All specifications have been tested according to the standard Chroma test procedures. All specifications are based on a remote sense connection, $25 \pm 1^{\circ}\text{C}$, and resistor load unless specified otherwise.

Model	61701	61702	61703	61704
AC OUTPUT RATING				
Max. Power	1500 VA	3K VA	4.5K VA	6K VA
Power per Phase	500 VA	1 K VA	1.5 K VA	2K VA
Voltage				
Range	150V / 300V			
Output Votlage	0~150V/0~300V, 0~140V/0~280V@>1000Hz			
Accuracy	0.2%+0.2%F.S.	0.2%+0.2%F.S.	0.2%+0.2%F.S.	0.2%+0.2%F.S.
Resolution	0.1 V	0.1 V	0.1 V	0.1 V
Distortion	0.3% @50/60Hz	0.3% @50/60Hz	0.3% @50/60Hz	0.3% @50/60Hz
	1.5%15- 1.2KHz	1.5%15- 1.2KHz	1.5%15- 1.2KHz	1.5%15- 1.2KHz
Line regulatoin	0.1%	0.1%	0.1%	0.1%
Load regulation	0.2%	0.2%	0.2%	0.2%
Temp. coefficient	0.02% per degree from 25°C			
Max. current (per Phase)				
r.m.s.	4A / 2A	8A / 4A	12A / 6A	16A / 8A
peak	24A / 12A	48A / 24A	72A / 36A	96A / 48A
Frequency				
Range	DC, 15-1.2K Hz	DC, 15-1.2K Hz	DC, 15-1.2K Hz	DC, 15-1.2K Hz
Accuracy	0.15%	0.15%	0.15%	0.15%
Phase				
Range	0 ~ 360°	0 ~ 360°	0 ~ 360°	0 ~ 360°
Resolution	0.3°	0.3°	0.3°	0.3°
Accuracy	<0.8°@50/60Hz	<0.8°@50/60Hz	<0.8°@50/60Hz	<0.8°@50/60Hz
DC OUTPUT RATING (per Phase)				
Power	250W	500W	750W	1K W
Voltage	212V / 424V	212V / 424V	212V / 424V	212V / 424V
Current	2A / 1A	4A / 2A	6A / 3A	8A / 4A
INPUT 3-PHASE AC POWER (per Phase)				
Voltage range	90-250V	90-250V	190-250V	190-250V
Frequency range	47-63 Hz	47-63 Hz	47-63 Hz	47-63 Hz
Current	9A Max.	16A Max.	10A Max.	14A Max.
Power Factor	0.97 Min.	0.98 Min.	0.98 Min.	0.98 Min.
MEASUREMENT				
Voltage				
Range	150V / 300V	150V / 300V	150V / 300V	150V / 300V

Accuracy	0.2%+0.2%F.S.	0.2%+0.2%F.S.	0.2%+0.2%F.S.	0.2%+0.2%F.S.
Resolution	0.1 V	0.1 V	0.1 V	0.1 V
Current				
Range (peak)	24A	48A	72A	96A
Accuracy (r.m.s.)	0.4%+0.3%F.S.	0.4%+0.3%F.S.	0.4%+0.3%F.S.	0.4%+0.3%F.S.
Accuracy (peak)	0.4%+0.6%F.S.	0.4%+0.6%F.S.	0.4%+0.6%F.S.	0.4%+0.6%F.S.
Resolution	0.01 A	0.01 A	0.01 A	0.01 A
Power				
Accuracy	0.4%+0.4% F.S.	0.4%+0.4% F.S.	0.4%+0.4% F.S.	0.4%+0.4% F.S.
Resolution	0.1 W	0.1 W	0.1 W	0.1 W
Others				
Efficiency	68 %	77 %	81 %	82 %
Size (W×H×D)	483 mm × 399 mm × 600 mm			
Weight	74 Kg	74 Kg	75 Kg	75 Kg
Protection	UVP, OCP, OPP, OTP, FAN			
Temperature range				
Operation	0 °C to 40 °C			
Storage	-40 °C to 85 °C			
Humidity	30 % to 90 %			
Safety & EMC	CE			

Remarks

*1 : Maximum distortion is tested on output 125VAC (150V RANGE) and 250VAC (300V RANGE) with maximum current to linear load.

*2 : Load regulation is tested with sinewave and remote sense.

*3 : Efficiency is tested on input voltage 61701/61702 : 110V, 61703/61704 : 220V.

1.4 Names of Parts

1.4.1 The Front Panel

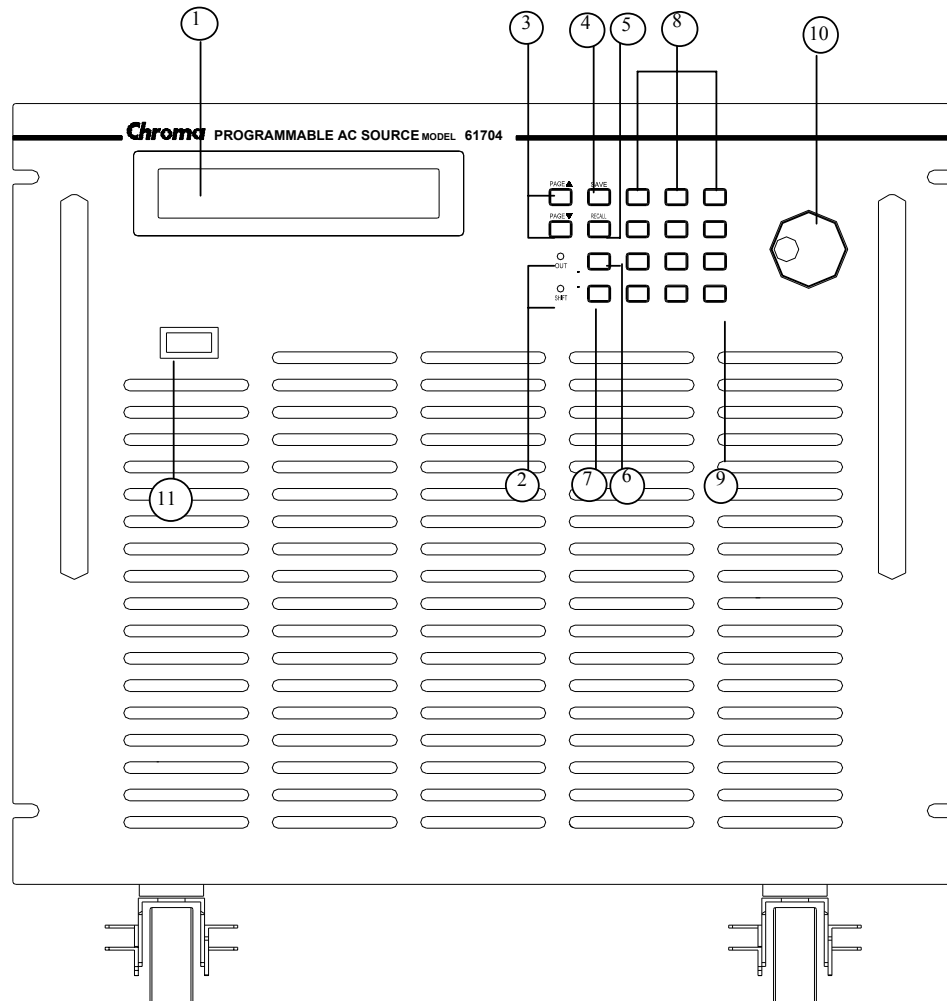
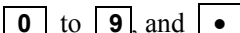


Figure 1-1 The Front Panel

Table 1-1 The Description of the Front Panel

Item	Symbol	Description
1		Display: The LCD is to display configuration, output setup, and measurement results.
2		Indicator LED: "OUT" and "SHIFT", for showing activation of output and shift mode, are available which are located on the keypad area next to the corresponding keys.
3	  -----or----- PAGE ▲ PAGE ▼	Cursor moving keys: These two keys are to move the cursor to different directions respectively. In normal mode, pressing any of these two keys will change the place of the cursor. Under shift mode, these keys enable the LCD display to change to last page or next page if there are ▲ or ▼ patterns in right-down side of display.
4	 -----or----- SAVE	PAGE or EXIT command key: Pressing this key will make the LCD display switching between MAIN PAGE and CHOICE PAGE. Or change to CHOICE PAGE in each functional list. Under shift mode, pressing this key on CHOICE PAGE, the user can save system data (see 3.8).
5	 -----or----- RECALL	Backspace and Minus command key: Pressing this key will erase the keyin number. Or it may show " - ", if no number is in front of cursor. Under shift mode, pressing the key on CHOICE PAGE, the user can recall system data (see 3.8).
6		OUT/QUIT command key: Pressing this key may enable the ac source output voltage or quit the output voltage.
7		Shift mode selection key: Pressing this key will switch the ac source from normal operational mode to the shift mode.
8	 -----or----- HELP	Numeric and decimal keys: The user can program numeric data by pressing the digital keys and the decimal key.
9		ENTER key: It is to confirm the setting of parameters.
10		RPG: The user can input programming data or options by turning the RPG to the desired ones.
11		Main power switch: It is to power on or off.

1.4.2 The Rear Panel

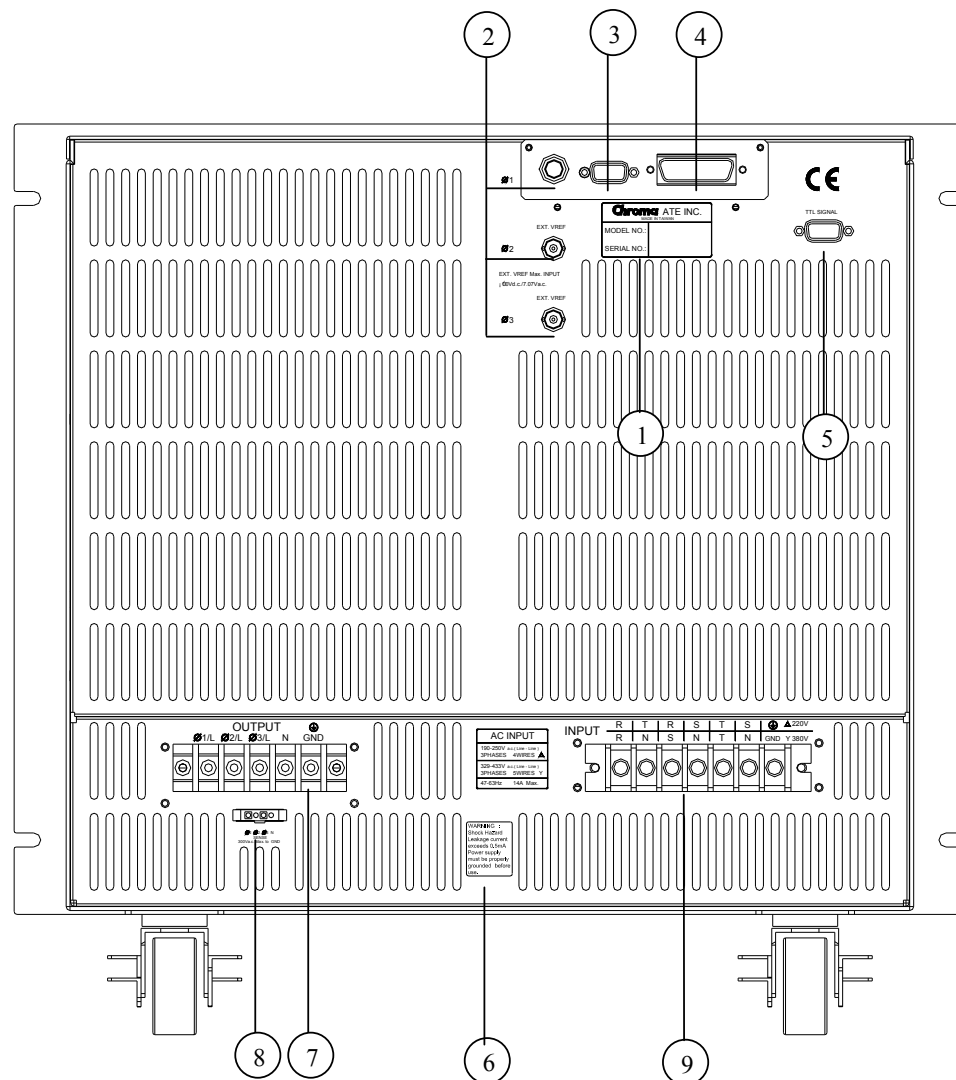


Figure 1-2 The Rear Panel

Table 1-2 The Description of the Rear Panel

Item	Name	Description
1	Label	The label includes model number, serial number of the AC source.
2	Ext. Ref.	The BNC connector inputs control waveform amplitude from external analog signal. (This function is reserved.)
3	RS-232C	The 9-pin, D-type female connector transfers control commands to and from the remote PC for remote operation.
4	GPIB Connector	A remote controller using GPIB bus is connected to the AC source through this connector for remote operation.
5	TTL SIGNAL	The 9-pin, female connector transfers control signals (fault_out, remote inhibit, and AC_ON). (See appendix A)
6	Warning Label	Warning the leakage current.
7	Output Connector	This connector outputs power to the loading device.
8	Remote Sense Connector	It senses directly at the terminals of the load to eliminate any voltage drop on the connecting cable. Reverse polarity is not allowed.
9	Power Line in Connector	Power line input is connected to the AC source through this connector.

2. Installation

2.1 Inspection

After unpacking the instrument, please inspect any damage that may have occurred during the shipment. Save all packing materials in case the instrument has to be returned one day.

If any damage is found, please file a claim with the carrier immediately. Do not return the instrument to the factory without obtaining the prior RMA acceptance from Chroma.

2.2 Preparation for the Use

In the beginning, the instrument must be connected with an appropriate AC line input. Then, since fans intelligently cool it, it must be installed in sufficient space for circulation of air. It should be used in an area where the ambient temperature does not exceed 40°C.

2.3 Requirements of Input Power

2.3.1 Ratings

Input Voltage Range	:	61701/61702 : 90 ~ 250 Vac, 3-phase 61703/61704 : 190 ~ 250 Vac, 3-phase
Input Frequency	:	47-63 Hz
Input Max. Current	:	61701 : 9 A 61702 : 16 A 61703 : 10 A 61704 : 14 A

Caution: The AC source will be damaged if it is operated at an input voltage that is outside its configured input range.

2.3.2 Input Connection

The input terminal block is located on the rear panel of the instrument. The power cord must be a four or five conductor cord rated at least for 85°C. The power line input must have a current rating that is greater than or equal to the maximum current rating of the AC source. Do not use three separate wires to connect power to the input of the AC source.

***** CAUTION *****

There are two different input voltage rating models. One is 380 V_{LL} 3 phases 5 wires (Y), and another is 220 V_{LL} 3 phases 4 wires (Δ). Be careful to verify that what kind of the main voltage you have.

See figure 2.3.2 (on the next page) and do the following things one by one:

1. Remove the safety cover from the back of the AC source.
2. Select the proper iron and screw the power cord to the input terminal blocks of the AC source (See Figure 2.3.2.1-a and 2.3.2.1-b)
3. Slip the safety cover over the ac input terminal strip, and secure the cover with four screws.

***** WARNING *****

To protect the operators, the wire connected to the GND terminal must be connected to the earth ground. Under no circumstances shall this AC source be operated without an adequate ground connection.

Installation of the power cord must be done by a professional and in accordance with local electrical codes.

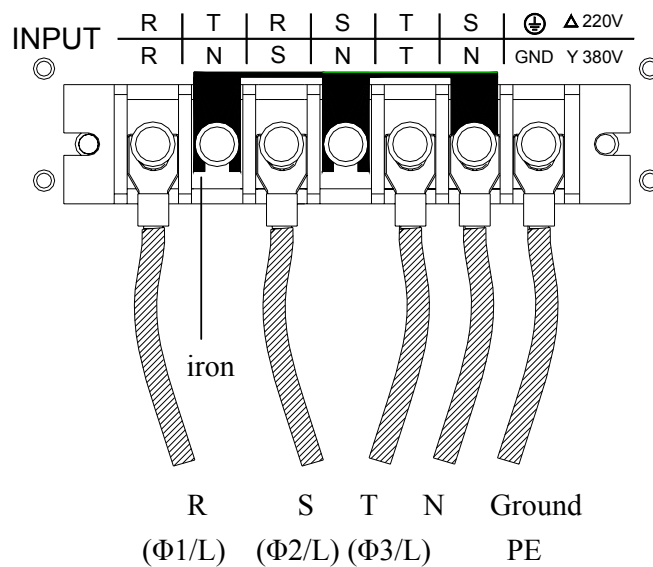


Figure 2.3.2.1-a 380 3~Y Input Connection

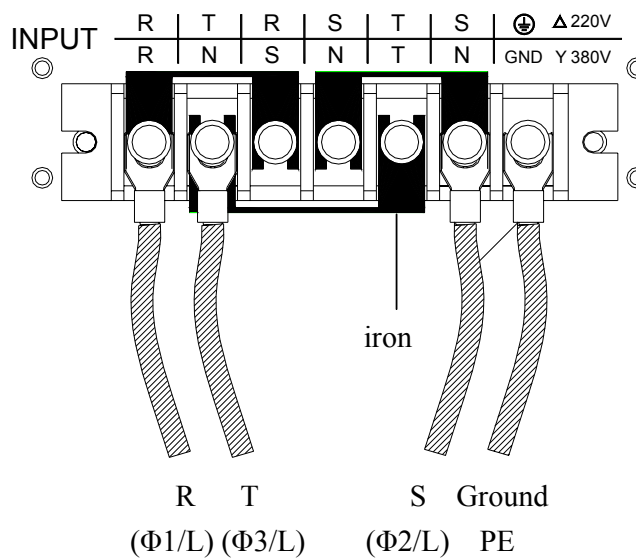


Figure 2.3.2.1-b 220 3~Δ Input Connection

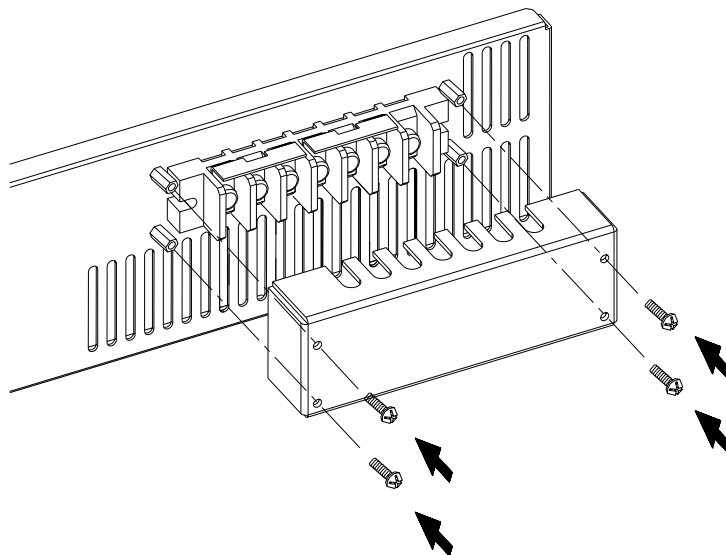


Figure 2.3.2.2 Input Terminal Safety Cover

2.4 Output Connection

The output terminal block is located in the rear of the AC source. Load connecting to the “ $\Phi 1/L$ ”, “ $\Phi 2/L$ ”, “ $\Phi 3/L$ ”, “N” and “G” are done at the output terminals. To meet the safety requirements, the safety cover must be fastened. The wires to the load must be sufficiently large gauges, so they will not overheat while carrying the output current. Please see figure 2.4.1.

***** NOTICE *****

Output terminal labeled "L" is the "+" terminal, terminal labeled "N" is the "-" terminal when output voltage contains DC composition.

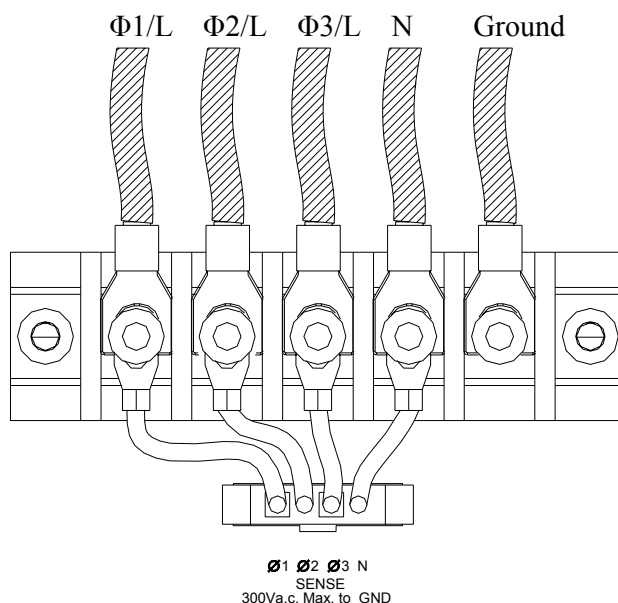


Figure 2.4.1 Output Terminal Connection

2.5 Remote Sense Connection

The remote sense function of the AC source monitors the voltage at the load instead at the output terminal of the AC source. It ensures the delivery of accurate voltage as programmed at the load by automatically compensating the output voltage drop over the connecting cable.

Connect the sensing leads as shown in Figure 2.5.1. Because the sensing leads carry only a few milliamperes, the wires for sensing are much lighter than the load leads. The sensing leads are part of the feedback path of the AC source, so they must be kept at a low resistance in order to maintain the best performance. Connect the sensing leads carefully so that they will not be open-circuited. If the sensing leads are left unconnected or become open-circuited during operation, the AC source will disable the output. The sensing leads must be a twisted pair to minimize the pickup of external noise. The sensing leads need to be connected to the load as close as possible.

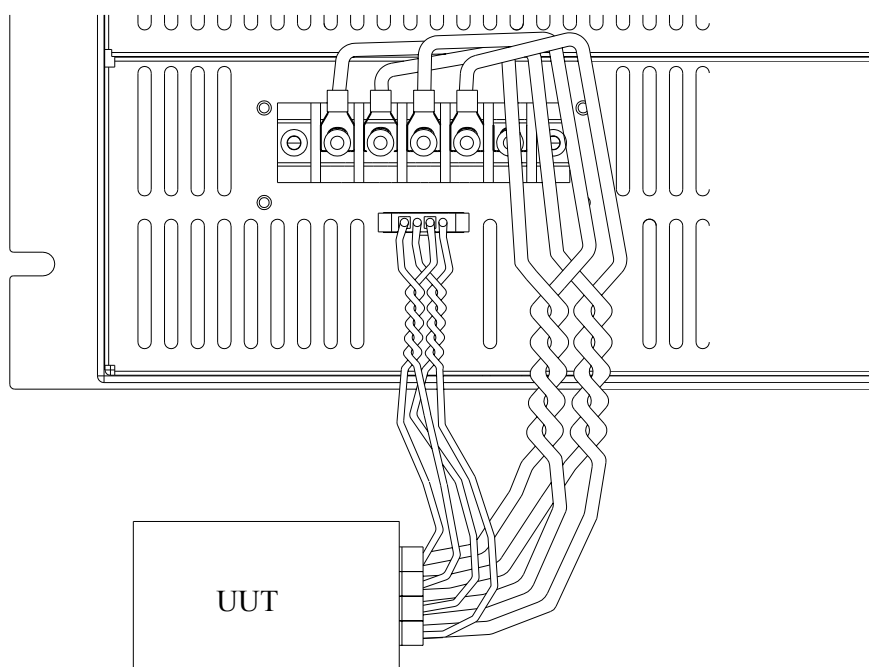


Figure 2.5.1 Output & Remote Sense Connection

2.6 The Procedures of Power-on

*** WARNING ***

Before turning on the instrument, all protective earth terminals, extension cords, and devices connected to the instrument must be connected to a protective earth ground. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.

Apply the line power and turn on the power switch on the front panel. The AC source will do a series of self-tests. The LCD on the front panel will light up and display as below:

Chroma Programmable AC Source

Meanwhile, the AC source do the memory, data and communication self-test. After the routines of the self-test be done, the display shows the MODEL number, and the serial number of the AC source, and it shows an “OK” at the right side of each test item indicating that the item is no problem. It takes about six seconds to complete the routines of the self-test. Then the display shows the versions of software as below.

1. SELF TEST

WAVEFORM1	OK	PANEL	OK
WAVEFORM2	OK	REMOTE	OK
WAVEFORM3	OK		

2. VERSION QUERY

WAVEFORM1	1.02	PANEL	1.02
WAVEFORM2	1.02	REMOTE	1.03
WAVEFORM3	1.02		

If any failure is detected on a certain item, an “ERROR CODE” will be shown at the right side of that item. The error messages and trouble-shooting are shown on section 6.2 in this manual. The test item " REMOTE " shows < EMPTY>, if the option board (with GPIB and RS-232) is not connected.

After finishing memory, data and communication self-test, the AC source do the power output self-test. In this procedure, the output relays are in OFF status to sure not harming the load connecting on output terminal. The AC source will program 300Vac to each phase and measure the voltage. If the measured voltage is over $300V \pm 5V$, the power self-test is failed, and the display will show "NG". If it's ok, the display is shown as below. Then, it changes to MAIN PAGE automatically.

3. OUTPUT TEST

WAVEFORM1	OK	MODEL: 61704
WAVEFORM2	OK	SERIAL NO.: 123456
WAVEFORM3	OK	

***** NOTICE *****

1. The user can do diagnosis if error or NG happens in power-on self-test procedure. Please see section 6.2 in this manual.
2. The inner digital circuit of AC source maybe not reset if turn off power then turn on immediately. Waiting more than 3 seconds is suggested to turn on power after turning off.

2.7 I/O Connectors (Option)

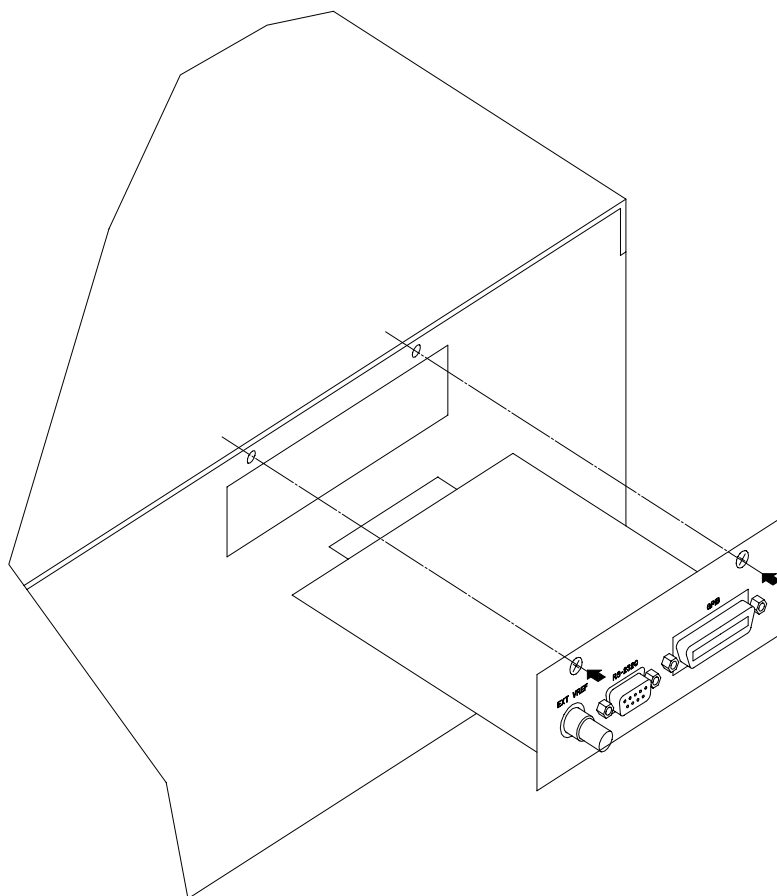


Figure 2.7.1 Option Board

This option board is for remote control interface: GPIB and RS-232.

3. Local Operation

3.1 Introduction

The AC source can be configured to operate in local or remote mode. The operation in remote mode through a remote GPIB controller or RS-232C will be described in Chapter 7. In this section the operation in local mode through the keypad on the front panel for data entry and test is going to be described. The AC source is configured for local operation when it is turned on.

3.2 Operation through Keypad and RPG

The AC source provides the user-friendly programming interface using the keypad and RPG (Rotary Pulse Generator) on the front panel to the user. Each display of the LCD on the AC source represents an operational menu.

The command tree is shown in Figure 3.2.1. Before describing each menu, the following show how to use keypad and RPG to set command. When the procedure of power-on is finished (see 2.6), the display will show MAIN PAGE as below.

Vac = 0.0_				H
Freq = 60.00		Pt = 0.0		
Vrms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00	▲
I rms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00	▼

If the parameter of V_SET of OUTPUT Functional list is INDIVIDUAL (see 3.7.1), the display will show MAIN PAGE as below.

Vac1 = 0.0_		Vac2 = 0.0	Vac3 = 0.0	H
Freq = 60.00		Pt = 0.0		
Vrms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00	▲
I rms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00	▼

Press ,  to move cursor to choose the item. Use numeric and decimal keys or RPG to set value, then press **ENTER** to confirm. The user can press **PAGE/EXIT** to change to

CHOICE PAGE as below. Or press **PAGE/EXIT** again to return to MAIN PAGE.

PAGE CHOICE = 1_

1. SETUP 2.CONF 3.OUTPUT 4. MANUAL CALI

In CHOICE PAGE, the user can press numeric key then **ENTER** to choose the functional lists. After entering each functional list, press **▲**, **▼** to move cursor to destination. If number expresses the settings, the user can use numeric and decimal keys or RPG to set value, then press **ENTER** to confirm. If words express the settings, the user can turn RPG to choose, then press **ENTER** to confirm.

If there are **▲** or **▼** patterns in right-down side of display, it means there are functional list on last page or next page. The user can press **SHIFT** then **▲** or **▼** to change page. If finish the setting, press **PAGE/EXIT** to return to CHOICE PAGE.

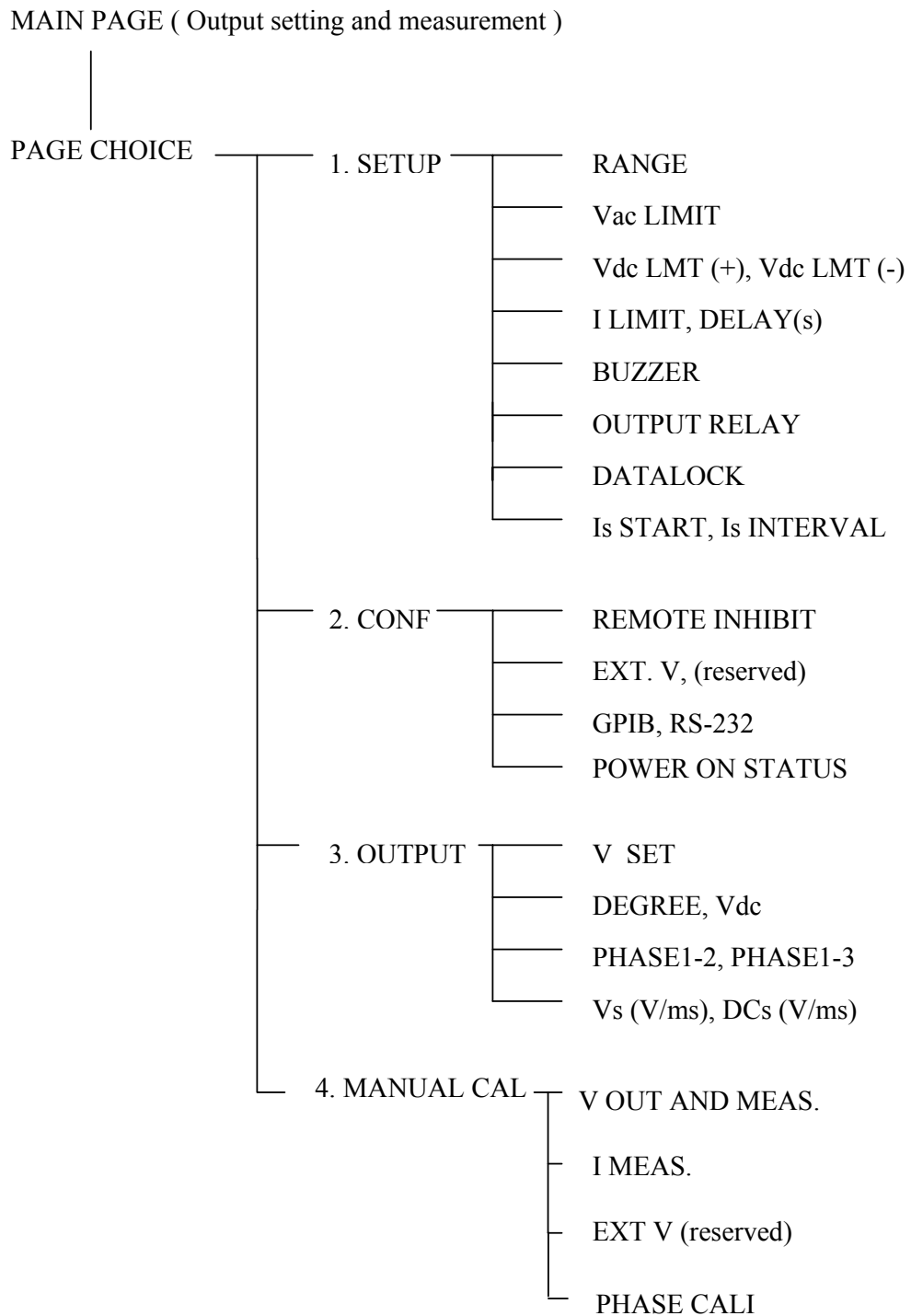


Figure 3.2.1

3.3 MAIN PAGE (Output Setting and Measurement)

When the user turn on the AC source, after self-testing steps, the display shows the MAIN PAGE. The upper line of display shows the output settings. The state of default output settings can be set on POWER ON STATUS in CONF functional list (see 3.6.4). The lower lines show the measurements of AC source output. Please see the following.

Vac	= 0.0_				H
Freq	= 50.00			Pt = 0.0	
Vrms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00		▲
I rms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00		▼

Press **SHIFT**, then  or  to change to next page. Please see the following.

Vac	= 0.0_				H
Freq	= 50.00			Pt = 0.0	
P	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00		▲
PF	Φ1 = 0.000	Φ2 = 0.000	Φ3 = 0.000		▼

If the parameter of V_SET of OUTPUT Functional list is INDIVIDUAL (see 3.7.1), the display will show MAIN PAGE as below.

Vac1 = 0.0_	Vac2 = 0.0	Vac3 = 0.0		H
Freq = 50.00			Pt = 0.0	
Vrms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00	▲
I rms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00	▼

On the right-up side of display, a letter "L" shows the status of RANGE (see 3.5.1). The definition of letters:

L : 150V RANGE
H : 300V RANGE

The definitions of output setting parameters:

Vac : It is the AC composition of output voltage in Volts.

Freq : It is the output frequency in Hertz.

***** NOTICE *****

When Vdc is set (see 3.5.3), the output is the combination of Vac and Vdc. But the combination of peak voltage cannot exceed the limit of each range (150V RANGE: 212.1V, 300V RANGE : 424.2V). If it is happened, the output voltage will quit to 0V automatically, and show the protection condition.

The definitions of measurement parameters:

V : It is the measurement readings of Voltage in Volts. (True RMS measurement)

I : It is the measurement readings of Current in Amperes. (True RMS measurement)

Freq : It is the output frequency in Hertz.

P : It is the true Power measurement in Watts.

PF : It is the Power Factor, and its calculation formula = true power/ (Vrms × Irms)

CF : It is the Crest Factor, and its calculation formula = Ipeak/Irms.

Vdc : It is the DC composition measurement readings of Voltage in Volts.

Idc : It is the DC composition measurement readings of Current in Amperes.

Ip : It is the peak current measurement in Amperes.

Is : It is I surge, and only measured from the occurrence of output transition as defined in 3.5.8.

VA : It is Apparent Power in Watts, and its calculation formula = Vrms × Irms.

VAR : Its calculation formula = $\sqrt{VA^2 - P^2}$

3.4 CHOICE PAGE (Functional List Choice)

If displays on MAIN PAGE or on functional list, press **PAGE/EXIT** to change to CHOICE PAGE as below:

PAGE CHOICE = 1_

1. SETUP 2.CONF 3.OUTPUT 4. MANUAL CALI

Users can press **[1]** - **[4]** to choose operational list item, then press **ENTER** to confirm it.

The display will switch to MAIN PAGE when press **PAGE/EXIT** on CHOICE PAGE.

3.5 SETUP Functional List

On CHOICE PAGE (see 3.4), press **[1]** then **ENTER**, choose the SETUP functional list.

PAGE CHOICE = 1_

1. SETUP 2.CONF 3.OUTPUT 4. MANUAL CALI

RANGE = 150V [SETUP]

Vac LIMIT = 300

Vdc LMT (+) = 424.2 Vdc LMT (-) = 0.0

I LIMIT (A) = 0.0 DELAY (s) = 0.0 ▼

Press **SHIFT**, then **▼** to change to next page.

BUZZER = ON OUTPUT RELAY = ON [SETUP]

DATALOCK = OFF

Is START = 0.0 ms

Is INTERVAL = 50.0 ms ▲

3.5.1 RANGE

The AC source supplies full range of output voltage with two options of 150 V, 300 V for each phase. The user can set RANGE on SETUP functional list (see section 3.5). This parameter controls relays to parallel (150V RANGE) or series (300V RANGE) power stages to obtain more current or higher voltage.

To set the range of output voltage as 150V as below:

1. Move the cursor to the command line of RANGE.

RANGE = 300V_

2. Turn the RPG to change the option from “300V” to “150V”, then press **ENTER**.

RANGE = 150V

***** NOTICE *****

The AC source will set output voltage as 0 V first in order to eliminate voltage spike when range changes. Then, it will set output voltage to new setting value. It may cause UUT to shut down or damaged if the output is active, when range changes.

3.5.2 Vac LIMIT

The setting of Vac LIMIT will restrict the value of Vac in MAIN PAGE. The user can set Vac LIMIT on SETUP functional list (see 3.5). This command is about user-programmable protection, not hardware protection.

The procedures for setting Current Vac LIMIT = 120V, are described as below:

1. Move the cursor to the command line of “Vac LIMIT = ”.

Vac LIMIT = 300.0_

2. Press **1**, **2**, **0** then press **ENTER** to change the value to “120.0”.

Vac LIMIT(A) = 120.0

***** NOTICE *****

The setting of Vac LIMIT is not restricted by RANGE, but the Vac on MAIN PAGE is restricted by RANGE. For example, in 150V RANGE, although Vac LIMIT= 200V, the largest value of Vac setting is 150V.

3.5.3 Vdc LIMIT (+), Vdc LIMIT (-)

Vdc LIMIT (+) and Vdc LIMIT (-) limit the setting value of Vdc on MAIN PAGE. The user can set both on SETUP functional list (see 3.5). The setting value of Vdc cannot be higher than Vdc LIMIT (+), or cannot be lower than Vdc LIMIT (-). Vdc LIMIT (+)

must be positive or zero, Vdc LIMIT (-) must be negative or zero. This command is about user-programmable protection, not hardware protection.

The procedures of setting Vdc LMT (+)=200V, Vdc LMT (-)=-50V are described as below:

1. Move the cursor to the command line of "Vdc LIMIT(+)=".

Vdc LMT(+) = 424.2_ Vdc LMT(-) = 0.0

2. Press **[2]**, **[0]**, **[0]** then press **ENTER** to change the value to "200.0".

Vdc LMT(+) = 200.0 Vdc LMT(-) = 0.0_

3. The cursor moves to the command line of "Vdc LIMIT(-) =" automatically.

Vdc LMT(+) = 200.0 Vdc LMT(-) = -50_

4. Press **[← / -]**, **[5]**, **[0]** then press **ENTER** to change the value to "-50.0".

Vdc LMT(+) = 200.0 Vdc LMT(-) = -50.0

***** NOTICE *****

1. The setting of Vdc LIMIT is not restricted by RANGE, but the Vdc on MAIN PAGE still restricted by RANGE. For example, in 150V RANGE, although Vdc LIMIT = 250V the largest value of Vdc setting is 212.1V.
2. When AC source output contains Vdc, it's better to restrict the value of Vdc. It may cause damage if output polarity is reverse, especially the load is polar.

3.5.4 I LIMIT, DELAY

Limitations of output RMS current, and delay time are the parameters for triggering over current protection. The user can set both on SETUP functional list (see 3.5). The discussion of limitation in this command is about user-programmable protection, not hardware protection.

The procedures of setting Current limit = 4A, Delay time = 1 sec., are described as below:

1. Move the cursor to the command line of "I LIMIT(A) =".

I LIMIT(A) = 0.00_ DELAY(S) = 0.0

2. Press **[4]**, then press **ENTER** to change the value to “4.00”.

I LIMIT(A) = 4_ DELAY(S) = 0.0

3. The cursor moves to the command line of “DELAY(S) = ” automatically.

I LIMIT(A) = 4.00 DELAY(S) = 0.0_

4. Press **[1]**, **ENTER** to change the value to “1.0”.

I LIMIT(A) = 4.00 DELAY(S) = 1.0_

***** NOTICE *****

1. When " I LIMIT (A) = 0 ", means the limitation of output current is equal to specification.
2. DELAY time is valid for eliminating transient current spike, but not work when the output current is over specification. The resolution is 0.5s.

3.5.5 OUTPUT RELAY

There are relays on the output of the AC source for the connection to load. When output relay is “ON”, it means that the output relay is closed in spite of that the output status of the AC source is in QUIT mode. When output relay is “OFF”, it means that the output relay is closed only as the output status is in RUN mode. If the output status is in QUIT mode, the output relay will be opened. The user can set OUTPUT RELAY on SETUP functional list (see 3.5).

To set the output relay as ON as below:

1. Move the cursor to the command of OUTPUT RELAY.

OUTPUT RELAY=OFF_

2. Turn RPG to set output relay ON, then press **ENTER**.
A click sound will be produced from the AC source when output relay is activated.

OUTPUT RELAY= ON

3.5.6 BUZZER

The buzzer of the AC source beeps when the user presses the keypad on the front panel, or turns the RPG knob. If the user does not need it, he can turn it off. The user can set BUZZER on SETUP functional list (see 3.5).

To turn off the buzzer as follows:

1. Move the cursor to the command line of "Buzzer=".

Buzzer = ON_

2. Turn RPG to change the option from ON to OFF, then press **ENTER**.

Buzzer = OFF

3.5.7 DATALOCK

The AC source allows the user to lock data entries, so the pre-defined parameters can be protected from being modified by an unauthorized person. The user can set DATALOCK on SETUP functional list (see 3.5).

The procedures of the setting data lock are shown as below:

1. Move the cursor to the command line of "DATALOCK=".

DATALOCK = OFF_

2. Turn RPG to change the option from OFF to ON, then press **ENTER**.

DATALOCK = ON

***** NOTICE *****

The user must select OFF to unlock.

3.5.8 Is START, Is INTERVAL

Is is the surge peak current of AC source output shown in MAIN PAGE. Is measurement starts at Is START after output voltage transition. The length of measurement time is Is INTERVAL. The user can set both on SETUP functional list (see 3.5).

The procedures of setting Is START=10ms, Is INTERVAL = 200 ms, are described as below:

1. Move the cursor to the command line of "Is START =".

Is START= 0.0_ ms

2. Press **[1]**, **[0]** then press **[ENTER]** to change the value to "10.0".

Is START = 10.0 ms

3. The cursor moves to the command line of "Is INTERVAL =" automatically.

Is INTERVAL = 50.0_ ms

4. Press **[2]**, **[0]**, **[0]** then press **[ENTER]** to change the value to "200.0".

Is INTERVAL = 200.0_ ms

3.6 CONF Functional List

On CHOICE PAGE (see 3.4), press **[2]** then **[ENTER]**, choose the CONF functional list.

PAGE CHOICE = 2_

1. SETUP 2.CONF 3.OUTPUT 4. MANUAL CALI

REMOTE INHIBIT = OFF

[CONF]

GPIB ADD = 30

PARITY = NONE

BAUD = 19200



Press **[SHIFT]**, then **[▼]** to change to next page.

POWER ON STATUS :

[CONF]

Output = OFF Freq = 60.00

Vac = 0.0

Vdc = 0.0



3.6.1 REMOTE INHIBIT

The output of the AC source can be inhibited by the external control or by manual trigger. The remote inhibit signal is received from 9-pin female connector on rear panel (see Appendix A). The user can set REMOTE INHIBIT on CONF functional list (see 3.6). There are three states for the feature of remote inhibit: OFF, LIVE, and TRIG.

- OFF : It is to disable the feature of remote inhibit.
- LIVE : The output of the AC source will be disabled if TTL signal is LOW, but will be automatically recovered if TTL signal is HIGH.
- TRIG : The output of the AC source will be disabled if TTL signal is LOW, and will remain even TTL signal becomes HIGH.

The procedures of setting from OFF to LIVE are shown as below:

1. Move the cursor to the command of "REMOTE INHIBIT" to set inhibition by the TTL signal from the external control.

REMOTE INHIBIT =OFF_

2. Turn RPG to change the option from OFF to LIVE, then press **ENTER**.

REMOTE INHIBIT =LIVE

*** NOTICE ***

The remote inhibit is a TTL signal transferred via the special I/O connector. For details please refer to pin assignment in Appendix A.

3.6.2 EXT. V, COUPLE (Reserved)

The AC source allows user to make use of the controlled analog signal from external devices for the setting of its output. The three BNC connectors of the EXT Vref on the rear panel lets the user apply signal to the AC source for the setting of 3-phase output voltage. The user can set EXT. V and COUPLE on CONF functional list (see section 3.6). There are two coupling mode to present AC source output from external V reference: AC_AMPLIFIER and DC_LEVEL_CTL.

AC_AMPLIFIER: The output voltage (Vout) is the synthesis of voltage programming on MAIN PAGE and the amplification of external V reference with voltage range from -10 V to 10 V. When Vac=0 and Vdc=0 on MAIN PAGE, Vout can be calculated using the following formula:

$$V_{out} (dc) = V_{ref} (dc) / 10 V_{dc} \times 424.2 V_{dc} \quad (300V \text{ RANGE})$$

$$V_{out} (dc) = V_{ref} (dc) / 10 V_{dc} \times 212.1 V_{dc} \quad (150V \text{ RANGE})$$

or

$$V_{out} (ac) = V_{ref} (ac) / 7.072 V_{ac} \times 300 V_{ac} \quad (300V \text{ RANGE})$$

$$V_{out} (ac) = V_{ref} (ac) / 7.072 V_{ac} \times 150 V_{ac} \quad (150V \text{ RANGE})$$

Example (1): set Vout to 100Vdc:

1. Select RANGE = 300V in SETUP functional list, apply external V= 2.357Vdc, the Vout = 100Vdc.
2. Select RANGE = 150V in SETUP functional list, apply external V= 4.715Vdc, the Vout = 100Vdc.

Example (2): set Vout to 100Vac:

1. Select RANGE = 300V in SETUP functional list, apply external V= 2.357Vac, the Vout = 100Vac.
2. Select RANGE = 150V in SETUP functional list, apply external V= 4.715Vac, the Vout = 100Vac.

DC_LEVEL_CTL : The output voltage (Vout (ac)) responses linearly proportional to the controlled DC level with voltage ranging from -10 V to 10 V.

Vout can be calculated using the following formula:

$$V_{out} (ac) = | V_{ref} (dc) | / 10 V_{dc} \times 300V_{ac} \quad (300V \text{ RANGE})$$

$$V_{out} (ac) = | V_{ref} (dc) | / 10 V_{dc} \times 150V_{ac} \quad (150V \text{ RANGE})$$

Example (1): set Vout to 100Vac:

1. Select RANGE = 300V in SETUP functional list, apply external V= 3.333Vdc (or -3.333Vdc), the Vout = 100Vac.
2. Select RANGE = 150V in SETUP functional list, apply external V= 6.667Vdc (or -6.667Vdc), the Vout = 100Vac.

The procedures of setting EXT. V = ON, COUPLE = DC_LEVEL_CTL, are described as below:

1. Move the cursor to the command of "EXT. V = ".

EXT.V = OFF_ COUPLE=AC_AMPLIFIER

2. Turn RPG to change the option from OFF to ON, then press **ENTER**.

EXT.V = ON COUPLE=AC_AMPLIFIER_

3. The cursor moves to the command line of "COUPLE =" automatically.

EXT.V = ON COUPLE=DC_LEVEL_CTL

4. Turn RPG to select DC_LEVEL_CTL, then press **ENTER**.

EXT.V = ON COUPLE=DC_LEVEL_CTL_

***** NOTICE *****

When EXT. V=ON, COUPLE=DC_LEVEL_CTL, the output voltage (Vout) will respond to the external control DC voltage level only. The user cannot control Vout amplitude through the keypad on the front panel, until EXT.V=OFF again.

***** WARNING *****

1. As COUPLE = AC_AMPLIFIER and the frequency of Vref is over 1200Hz, it might cause AC source damage. The user should obey the formula if $F > 1200\text{Hz}$:

$$V_{\text{ref}} (\text{pk-pk, V}) \times F (\text{Vref, Hz}) < 10000 \text{ VHz}$$
2. Because of the bandwidth limitation of AC source, the output may distortion. Especially when external V reference consists of high frequency composition.

3.6.3 GPIB Address, RS-232C

The AC source offers the mode of remote operation too. The user can set them on CONF functional list (see 3.6). For details please refer to Chapter 7. Prior to remote operation the user has to set the GPIB address 10 as below:

1. Move the cursor to the command line of GPIB address.

ADDR = 30_

2. Press **1**, **0**, **ENTER** to set address 10.

ADDR = 10

***** NOTICE *****

Addressing space ranges from 1 to 30.

The AC source offers another remote operation through the RS-232C bus.

Communication protocol is set as follows:

To set parity=ODD, baud rate=19200.

1. Move the cursor to the command line of PARITY.

PARITY= NONE_ BAUD=9600

2. Turn RPG to select ODD, then press **ENTER**.

PARITY=ODD BAUD=9600_

3. The cursor moves automatically to the setting position of "BAUD".

Turn RPG to select "19200", then press **ENTER**.

PARITY=ODD BAUD=19200

***** NOTICE *****

The options of baud rate are 9600/19200. The options of parity are EVEN/ODD /NONE.

3.6.4 POWER ON STATUS

The AC source allows the user to set the status of the output when power is switched on. The user can set POWER ON STATUS on CONF functional list (see 3.6). After setting, the user should save them before powering off (see 3.8.2). User also can pre-set voltage of each phase individually if V_SET = INDIVIDUAL (see 3.7.1).

To set the output is ON, as 230 Vac, 50Hz, 0Vdc when power-on.

1. Move the cursor to the line of "POWER ON STATUS : Output =".

POWER ON STATUS : Output = OFF_

2. Turn RPG to set output ON, then press **ENTER**.

POWER ON STATUS : Output = ON

3. Press **2** , **3** , **0** , **ENTER** to set Vac=230.

Vac = 230.0 Freq=60.0_ Vdc = 10.0

4. Press **5** , **0** , then press **ENTER** to set Freq=50.

Vac = 230.0 Freq=50.0 Vdc = 10.0

5. Press **0** , then press **ENTER** to set Vdc = 0.

Vac = 230.0 Freq=50.0 Vdc = 0.0

3.7 OUTPUT Functional List

On CHOICE PAGE (see 3.4), press **3** then press **ENTER**, choose the OUTPUT functional list.

PAGE CHOICE = 3_

1. SETUP 2.CONF 3.OUTPUT 4. MANUAL CALI

V_SET = ALL

[OUTPUT]

DEG ON = 0.0

DEG OFF = IMMED

Vdc = 0.0



Press **SHIFT** , then to change to next page.

[OUTPUT]

Phase 1-2 = 120.0

Phase 1-3 = 240.0

Vs (V/ms) = 0.000

DCs (V/ms) = 0.000



3.7.1 V_SET

There are two mode of AC source output setting: ALL and INDIVIDUAL. The user can set V_SET on OUTPUT functional list (see 3.7) to fit the application. Then, the display of MAIN PAGE will change corresponding to the mode.

If V_SET = ALL, voltage setting of 3-phase output are all the same. The MAIN PAGE is as below.

Vac	= 0.0_			H
Freq	= 50.00		Pt = 0.0	
P	$\Phi 1 = 0.0$	$\Phi 2 = 0.0$	$\Phi 3 = 0.0$	▲
PF	$\Phi 1 = 0.00$	$\Phi 2 = 0.00$	$\Phi 3 = 0.00$	▼

If V_SET = INDIVIDUAL, voltage setting of 3-phase output can be set individually. The MAIN PAGE is as below.

Vac1	= 0.0_	Vac2 = 0.0	Vac3 = 0.0	H
Freq	= 50.00		Pt = 0.0	
Vrms	$\Phi 1 = 0.0$	$\Phi 2 = 0.0$	$\Phi 3 = 0.0$	▲
I rms	$\Phi 1 = 0.00$	$\Phi 2 = 0.00$	$\Phi 3 = 0.00$	▼

The procedures of setting from ALL to INDIVIDUAL are shown as below:

1. Move the cursor to the command of "V_SET="

COUPLE = ALL_

2. Turn RPG to change the option from ALL to INDIVIDUAL, then press **ENTER**.

COUPLE= INDIVIDUAL

3.7.2 Output Degree

The AC source can control the transition angle of the waveform when it out or quit. The user set DEG ON and DEG OFF to achieve it in OUTPUT functional list (see 3.7)

The procedures for setting output phase angle DEGREE ON = 90 and OFF=180, are described as below:

1. Move the cursor to the command line of "ON =".

DEG ON = 0.0_ DEG OFF= IMMED

2. Press **[9]**, **[0]**, then **ENTER** to change the value to "90.0".

DEG ON = 90.0 DEG OFF= IMMED_

3. The cursor moves to the command line of "OFF=" automatically.

4. Press **[1]**, **[8]**, **[0]**, then press **ENTER** to change the value to "180.0".

DEG ON = 90.0 DEG OFF= 180.0

***** NOTICE *****

1. The output or quit phase angle of waveform is set for Phase 1 ($\Phi 1$). The other phases will follow Phase 1 to out or quit at the same time.
2. If "OFF=IMMED", the output voltage quits immediately when the user presses **QUIT**. But if a value of degree is set, the output voltage will last until the setting degree. Keyin "OFF= 360" became "OFF= IMMED".

3.7.3 Vdc Output

The AC source can program output voltage that contains DC component by setting Vdc on OUTPUT functional list (see 3.7). User also can set DC component of each phase individually if V_SET = INDIVIDUAL (see 3.7.1).

The procedures of setting Vdc = 2V is described as below:

1. Move the cursor to the command line of "Vdc =".

Vdc = 0.0_

2. Press **[2]**, then press **ENTER** to change the value to "2.0".

Vdc = 2.0

***** NOTICE *****

The DC component of AC source output is applied to doing some voltage tests. The AC source has not such many output capacitors, some feature like voltage ripple, load transient, are not like DC source.

3.7.4 Phase Angle Setting

For a 3-phase AC power system, the phase angle between each is 120° . The AC source of 61700 can program the phase angle $0\sim 360^\circ$, not fix on 120° . The user set PHASE 1-2 and PHASE 1-3 to achieve it in OUTPUT functional list (see 3.7). The parameter of PHASE 1-2 means phase angle between Phase 1 ($\Phi 1/L$) and Phase 2 ($\Phi 2/L$).

The procedures of setting a balance phase angle is described as below:

1. The cursor moves to the command line of "PHASE 1-2=".

PHASE 1-2=0.0 PHASE 1-3 =0.0

2. Press **[1]**, **[2]**, **[0]**, then press **ENTER**.

PHASE 1-2=120.0 PHASE 1-3 =0.0_

3. The cursor moves to the command line of "PHASE 1-3=" automatically.

4. Press **[2]**, **[4]**, **[0]**, then press **ENTER**.

PHASE 1-2=120.0 PHASE 1-3 =240.0_

*** NOTICE ***

Users cannot connect $\Phi 1/L$, $\Phi 2/L$, $\Phi 3/L$ terminals of AC source outputs together, even set the PHASE 1-2 = 0 and PHASE 1-3 = 0.

3.7.5 Slew Rate of Output Transient

The AC source can control the transition waveform of the output by setting Vs and DCs on OUTPUT functional list (see 3.7). User can set two commands to achieve the transient state of output waveform: Vs (V/ms), DCs (V/ms).

Vs : the slew rate of output Vac.

DCs : the slew rate of output Vdc.

When user run OUT of AC source or change the output setting in MAIN PAGE, the output voltage will change corresponding to the Vs, DCs commands.

The procedures of setting V_s (V/ms)=0.2, DCs (V/ms)=0.1, are described as below:

1. Move the cursor to the command line of “ V_s (V/ms) = ”.

V_s (V/ms) = 0.000_

2. Press **[0]**, **[.]**, **[2]**, then press **ENTER** to change the value to “0.2”.

V_s (V/ms) = 0.200

3. The cursor moves to the command line of “DCs (V/ms)=” automatically. Press **[0]**, **[.]**, **[1]**, then press **ENTER**.

DCs (V/ms) = 0.100_

***** NOTICE *****

1. When user set V_s (V/ms)=0, DCs (V/ms)=0, the output transient is in the fastest speed.
2. V_s , F_s DCs have large input range in software programming, but the output might not exactly follow the slew rate when V_s , DCs are too large.
3. When user run **OUT** of AC source, the output will follow the setting to final state. But when user run QUIT, the output will vary to 0 V immediately. If user want to quit the output with the setting slew rate, he must keyin 0 V then press **ENTER**.

3.8 Save and Recall

The AC source offers two modes for the user to save and recall output setting or system data. They are described in 3.8.1 and 3.8.2.

3.8.1 Save and Recall Output Setting

The AC source offers nine channels for the user to save a set of frequently used Vac, F, Vdc, and to recall them for later use.

Under the MAIN PAGE:

Vac1 = 0.0_	Vac2 = 0.0	Vac3 = 0.0	H
Freq = 60.00		Pt = 0.0	
Vrms	$\Phi 1 = 0.00$	$\Phi 2 = 0.00$	$\Phi 3 = 0.00$
I rms	$\Phi 1 = 0.00$	$\Phi 2 = 0.00$	$\Phi 3 = 0.00$
			▲
			▼

Press **SHIFT**, then **PAGE/EXIT**, to run the SAVE function. The display will show as below:

CHOICE 1-9, PRESS <ENTER> TO SAVE			
1_	Vac1= 0.0	Vdc1= 0.0	
	Vac2= 0.0	Vdc2= 0.0	
	Vac3= 0.0	Vdc3= 0.0	F=60.00

The user can press **1** - **9** to select channel, then press **ENTER** to save the output settings. Then, press **PAGE/EXIT** to return to MAIN PAGE.

Recalling from memory channel to MAIN PAGE is shown the following: In MAIN PAGE, press **SHIFT** then **← / -** to run the RECALL function. The display will show as below:

CHOICE 1-9, PRESS <ENTER> TO RECALL			
1_	Vac1= 100.0	Vdc1= 20.0	
	Vac2= 100.0	Vdc2= 20.0	
	Vac3= 100.0	Vdc3= 20.0	F=60.00

The user can press **1** - **9** to select channel, then press **ENTER** to recall the output setting. After that, the display returns to MAIN PAGE automatically.

If the recalling settings are output of RANGE or over the V LIMIT (see 3.5.2, 3.5.3), the display will show the following:

Conflicting with RANGE or V LIMIT	
Press <ENTER> key to Exit	

*****NOTICE*****

1. To save and recall output settings are for MAIN PAGE setting only, the other parameters are ignored.
2. If V_SET=ALL(see 3.7.1), the recalling settings to MAIN PAGE are defined to Vac1, Vdc1.

3.8.2 Save and Recall System Data

The AC source offers three memory groups for the user to save system data and to recall them for later use. The system data includes all parameters in function list like measurement settings, SETUP (see 3.5), CONF (see 3.6) and OUTPUT (see 3.7). In the CHOICE PAGE (see 3.4), press **SHIFT**, then **PAGE/EXIT**, to run the SAVE function. The displays are shown as below.

PAGE CHOICE = 1_
1. SETUP 2.CONF 3.OUTPUT 4. MANUAL CALI

Save all parameters to Group (1 - 3) : 1_

Press **1** - **3** to choose one group to save, then press **ENTER** to confirm. The display will show the saving status sentence about three seconds as below.

Save all parameters to Group (1 - 3) : 1_

Saving now, do not shut down

Then, press **PAGE/EXIT** to return to CHOICE PAGE.

Recalling system data from memory group is shown the following: In CHOICE PAGE, press **SHIFT** then **↵ / -** to run the RECALL function. The display will show as below:

Recall parameters of Group (1 - 3) : 1_

Press **1** - **3** to choose one group to recall, then press **ENTER** to confirm. Then, the display will return to CHOICE PAGE after loading the data.

***** NOTICE *****

The AC source provides three memory groups: 1, 2, and 3. The memory group 1 keeps power-on defaults. The setup data saved into memory group 1 will be recalled automatically when the AC source is powered on again. Those saved in other memory groups must be recalled manually.

3.9 Protection

The AC source provides protection for software and hardware. When protection is happened, the AC source will quit the output and turn off the output relays, then show the condition of protection in display. If any protection is triggered to hold normal output, please remove the errors, then press **ENTER** to unlock the protection so as to resume the normal operation.

Protection for software are listed as below:

Protection	Description
OVER CURRENT	When output current is over the I limit or the current specification.
OVER POWER	When output power is over the specification.
OUTPUT OVP	1. It is feedback open protection, and means that the feedback loop is broken or the output voltage goes wrong. 2. When the out voltage is over the limit of each RANGE. See 3.3.

Protection for hardware are listed as below:

Protection	Description
FAN FAIL	It is fan failure protection, and means that the cooling fan malfunctions.
INT - AD	It is inner AD power stage (see 5.1) protection, and means that the output voltage is over or under the specific value.
INT - DD	It is inner DD power stage (see 5.1) protection, and means that the output voltage is over or under the specific value.
OUTPUT SHORT	It is short protection, and means that the output terminals are shorted.
INPUT FAIL	It is power failure protection, and means that the line input voltage is lower or higher than specification.
OVER TEMP	It is over temperature protection, and will be enabled when the internal temperature of the AC source is too high.

4. Calibration

4.1 Introduction

The AC Source built a simple way to calibrate the 3-phase output and measurement accuracy without opening cover. Users can do it for each phase just follow the procedures step by step. A voltage meter, current meter, suitable load and +5V DC Source are needed for while calibration procedure. Connections for these instruments please refer to Figure 4.1.1. There are three items need to calibrate. But it is not necessary to calibrate all at once. User can just choose one item if needs.

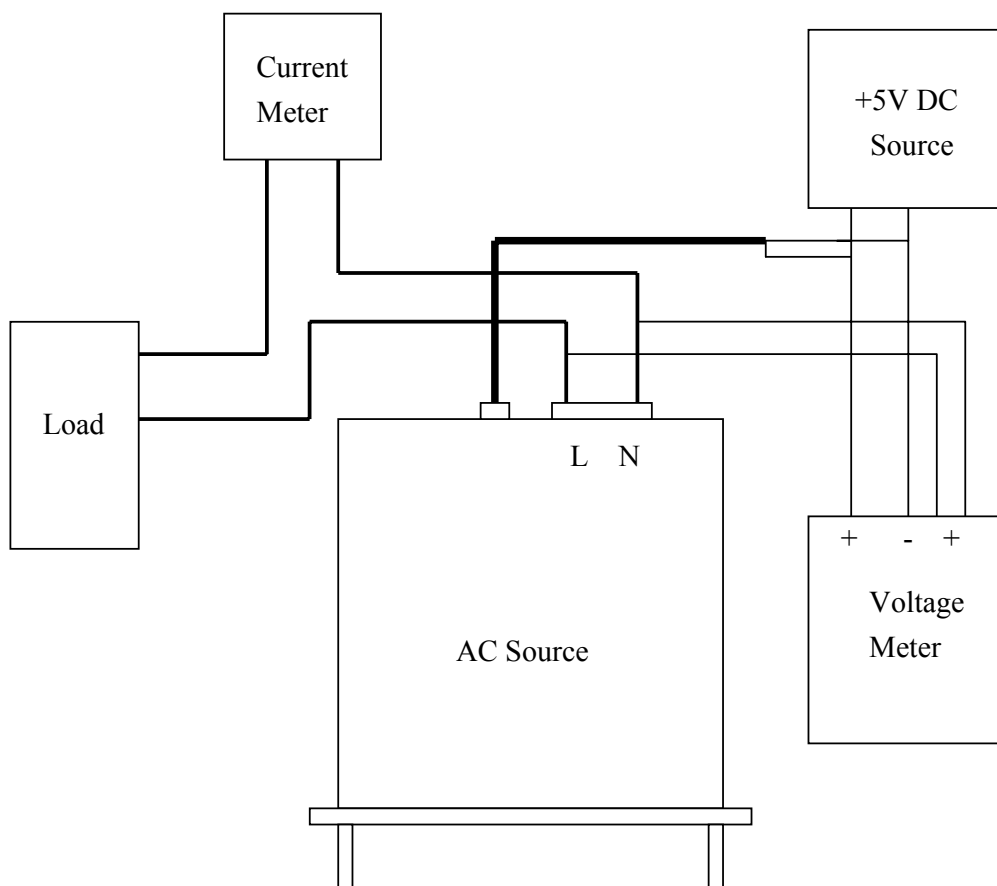


Figure 4.1.1

4.2 MANUAL CALI Functional List

Users can choose "4. MANUAL CALI " in CHOICE PAGE to enter the calibration procedure. Before showing the calibration items, for safety reason, user must enter password. The password is shown in this manual, in order to confirm the user read the manual before doing the calibration procedure.

PAGE CHOICE = 4_
1. SETUP 2.CONF 3.OUTPUT 4. MANUAL CALI

Enter Password : _
(You can get password in user's manual !)

Enter Password : * * * * _
(You can get password in user's manual !)

*** NOTICE ***

1. The password of entering calibration procedure is " 7377 ", then press **ENTER**.
2. Before calibrating the AC source, users should read the procedure in details.
Or it may lose some data in memory because of improper operation.

After keyin the correct Password, the display shows PHASE CHOICE PAGE.

PHASE CHOICE = 1_
1. PHASE 1 2. PHASE 2 3. PHASE 3 4. PHASE CALI

Choose the phase you want to calibrate, the display shows CALIBRATION CHOICE PAGE.

CALIBRATION CHOICE = 1_ 1. V OUT AND MEAS. 2. I MEAS. 3. EXT Vref.

V OUT AND MEAS.: output voltage and voltage measurement accuracy calibration.

I MEAS.: current measurement accuracy calibration.

EXT Vref.: external Vref calibration.

4.2.1 Output Voltage and Voltage Measurement Calibration

On CALIBRATION CHOICE page, press **1**, **ENTER** to do the output voltage and voltage measurement calibration.

CALIBRATION CHOICE = <u>1</u> 1. V OUT AND MEAS. 2. I MEAS. 3. EXT V.
--

Please Remove Load Before Calibrating Press <ENTER> to start

1. V OUT AND MEAS. ACCURACY CALI 150V RNG A. KEYIN THE MEASURED Vdc Vdc offset = _ mV ▼
--

In this step A of V OUT AND MEAS. ACCURACY CALI, the user should keyin the AC source's DC output voltage measured by digital voltage meter (DVM) in mV. Then,

monitor the reading of DVM, keyin the DC output voltage repeatedly until DC output is less than ± 10 mV.

***** NOTICE *****

1. The Vdc offset may be positive or negative. The positive of DVM connect to the line of AC source output, and the negative of DVM connect to the Neutral of AC source output. See Fig. 4.1.1.
2. The load must be off at all steps of V OUT AND MEAS. ACCURACY CALI.

Then press **SHIFT**, then **▼** to change to next step.

1. V OUT AND MEAS. ACCURACY CALI 150V RNG
B. WAIT TWO SECONDS THEN (ENTER)

Vac = 0.00 V Vdc = 0.00 V



In this step B of V OUT AND MEAS. ACCURACY CALI., the display shows the offset of Vac and Vdc measured by AC source. They are produced by internal components. Wait two seconds then press **ENTER**, then Vac = 0.00, Vdc = 0.00.

***** NOTICE *****

The AC source calibration steps are allowed to do individually, but it is better to follow the calibration procedure step by step (step A, step B ...). Or it may cause output and measurement errors.

Then press **SHIFT**, then **▼** to change to next step.

1. V OUT AND MEAS. ACCURACY CALI 150V RNG
C. (ENTER) THEN CHECK OUTPUT IS 15VAC
D. (ENTER) THEN KEYIN DVM MEAS. 150VAC
0.00_ V



Then go to next step D. Press **ENTER**, check the output voltage measured by DVM is about 150VAC. Keyin the exact value measured by DVM, then press **ENTER**.

1. V OUT AND MEAS. ACCURACY CALI 300V RNG
 E. (ENTER) THEN CHECK OUTPUT IS 30VAC
 F. (ENTER) THEN KEYIN DVM MEAS. 300VAC
 0.00 _ V 

Then go to next step F. Press **ENTER**, check the output voltage measured by DVM is about 300VAC. Keyin the exact value measured by DVM, then press **ENTER**.

Press (ENTER) to save .
Press (PAGE/EXIT) not to save .

4-5

4.2.2 Current Measurement Calibration

On CALIBRATION CHOICE page, press **2**, **ENTER** to do the current measurement calibration.

CALIBRATION CHOICE = <u>2</u>	
1. V OUT AND MEAS.	2. I MEAS.
3. EXT Vref.	

1. CURRENT MEAS. ACCURACY CALI 150V RNG	
<u>A</u> . WAIT TWO SECONDS THEN (ENTER)	
Iac = 0.00 A	Idc = 0.00 A ▼

In above step A of CURRENT MEAS. ACCURACY CALI., the display shows the offset of Iac and Idc measured by AC source. They are produced by internal components. Wait two seconds then press **ENTER**, then Iac = 0.00A, Idc = 0.00A.

Then press **SHIFT**, then ▼ to change to next step.

1. CURRENT MEAS. ACCURACY CALI 150V RNG	
B. (ENTER) THEN CHECK CURRENT IS 1.6A	
C. (ENTER) THEN KEYIN CURRENT MEAS. 16A	
0.00 A	▲

In above step B of CURRENT MEAS. ACCURACY CALI., press **ENTER** then AC source will output 12.5VAC. The user should apply suitable load to output, to make the output current measured by current meter (or power analyzer) be about 1.6A (for 61704). The different model shows different current value in display. If the output current is ok after applying load, press **ENTER**, then AC source will output 125VAC. The output current will be 10 times of step B, 16A. Keyin the exact value of current measured by current meter. The output current of step B. and step C. are shown as below:

Model	Step B.	Step C.
61701 (500 VA)	0.4 A	4 A
61702 (1000 VA)	0.8 A	8 A
61703 (1500 VA)	1.2 A	12 A
61704 (2000 VA)	1.6 A	16 A

Step C is the final step of CURRENT MEAS. ACCURACY CALI. Press **PAGE/EXIT** to exit that page. Then display will show as below. Press **ENTER** to save the calibration result.

Press (ENTER) to save .
Press (PAGE/EXIT) not to save .

***** NOTICE *****

1. The resistance of applied load must be constant, so that the load current is proportional to output voltage. If not, the step B of CURRENT MEAS. ACCURACY is insignificant. Users only need to meet the current of step C When output voltage is 125VAC.
2. When doing the procedure of calibration, the protection is removed temporarily. It may cause damage of AC source if applying unsuitable load.

4.2.3 External Vref Calibration (Reserved)

On CALIBRATION CHOICE page, press **3**, **ENTER** to do the external Vref calibration. See details as below.

CALIBRATION CHOICE = 3
 1. V OUT AND MEAS. 2. I MEAS.
 3. EXT Vref.

Please Remove Load Before Calibrating

Press <ENTER> to start

3. EXTERNAL Vref CALI 150V RANGE

A. Vref INPUT SHORT

WAIT TWO SECONDS THEN (ENTER)

Vdc = 0.00 V

In above step A of EXTERNAL Vref CALI., short the external Vref input terminal to make input is 0V, then the display shows the measured Vdc from AC source. They are offset voltages produced by internal components. Wait two seconds then press **ENTER**, then Vdc = 0V.

Then press **SHIFT**, then **▼** to change to next step.

3. EXTERNAL Vref CALI 150V RANGE

B. INPUT EXT. V 5VDC - WAIT TWO SECOND

KEYIN EXT. V DVM MEAS.

0.000

VDC

(ENTER)



In above step B of EXTERNAL Vref CALI., the user apply +5Vdc to Vref BNC connector from outer DC source. Check the output voltage of AC source is about 106Vdc, then keyin the exact value of input Vref voltage (not AC source output) measured from DVM.

Step B is the final step of EXTERNAL Vref CALI. Press **PAGE/EXIT** to exit that page. Then display will show as below. Press **ENTER** to save the calibration result.

Press (ENTER) to save .

Press (PAGE/EXIT) not to save .

4.2.4 Phase Angle Calibration

In order to get better accuracy of phase angle between each output voltage, especially at high frequency, 61700 series AC source allow users to calibrate it. You can choose 4 into phase offset calibration at PHASE CHOICE PAGE (see 4.2).

```

PHASE CHOICE = 4_
1. PHASE 1  2. PHASE 2  3. PHASE 3  4. PHASE_CALI
  
```

Please Remove Load Before Calibrating!

Press <ENTER> to start

Confirm no load is connected, press **ENTER** to phase offset calibration.

```

4. PHASE  OFFSET  CALI.
L12Dly= 00.0 us    L13Dly= 00.0 us
Vac1=0.00_         Vac2=0.00         Vac3=0.00
L12=0.000          L13=0.000
  
```

L12Dly= 00.0 us and L13Dly= 00.0 us are just for reference.

- Step A: Measure the voltage between $\Phi 1/L$ to N about 50VAC, then keyin the exact value measured by DVM to Vac1, then press **ENTER**.
- Step B: Measure the voltage between $\Phi 2/L$ to N about 50VAC, then keyin the exact value measured by DVM to Vac2, then press **ENTER**.
- Step C: Measure the voltage between $\Phi 3/L$ to N about 50VAC, then keyin the exact value measured by DVM to Vac3, then press **ENTER**.
- Step D: Measure the voltage between $\Phi 1/L$ to $\Phi 2/L$ about 86.6VAC, then keyin the exact value measured by DVM to L12, then press **ENTER**.
- Step E: Measure the voltage between $\Phi 1/L$ to $\Phi 3/L$ about 86.6VAC, then keyin the exact value measured by DVM to L13, then press **ENTER**.

Phase offset calibration is finished after above steps are done. Press **PAGE/EXIT** to exit this page.

***** NOTICE *****

1. The output is 50Vac/400Hz in this calibration procedure. In order to get a accuracy result, please use a high performance DVM like Agilent 34401A.
2. The calibration result will keep until power off the AC source. Because the phase angle error is different at every time power on the AC source. Users must calibrate every time if they want get better accuracy.

5. Theory of Operation

5.1 Description of Overall System

Figure 5.1.1 shows the overall system. Main power flows through 3 modules of power transfer unit. The A board is identified as user interface controller. It scans front panel keys through K board, and sends settings and measurement messages on LCD module. The optional E board performs remote control through GPIB, RS-232C interface.

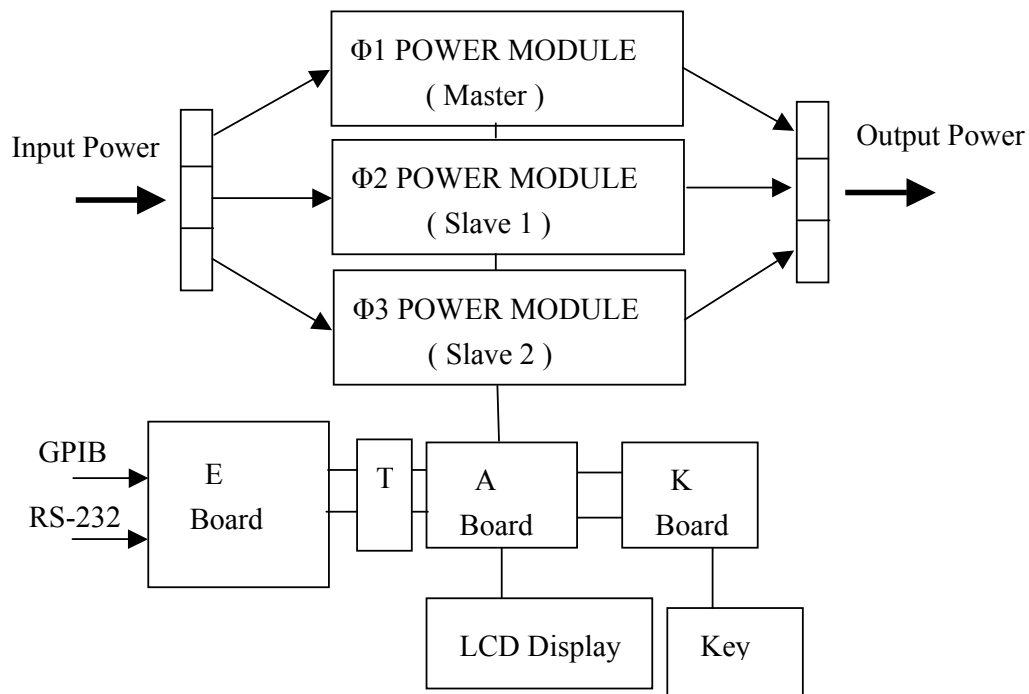


Figure 5.1.1 The Structure of 61700

5.2 Description of Power Transfer Unit

Figure 5.2.1 shows the power transfer unit. The A/D power stage is designated as I board, and generates DC voltage from the line input. The G board of D/D stage takes power from the A/D output. It generates two isolated DC outputs for D/A power stage. The H board of D/A inverter generates AC output. The D/A power stage is through G board relays in parallel or series control to obtain more current and higher voltage. B board is identified as DSP processor and D/A controller. The DSP processor is applied to control output frequency and voltage, to measure voltage and current.

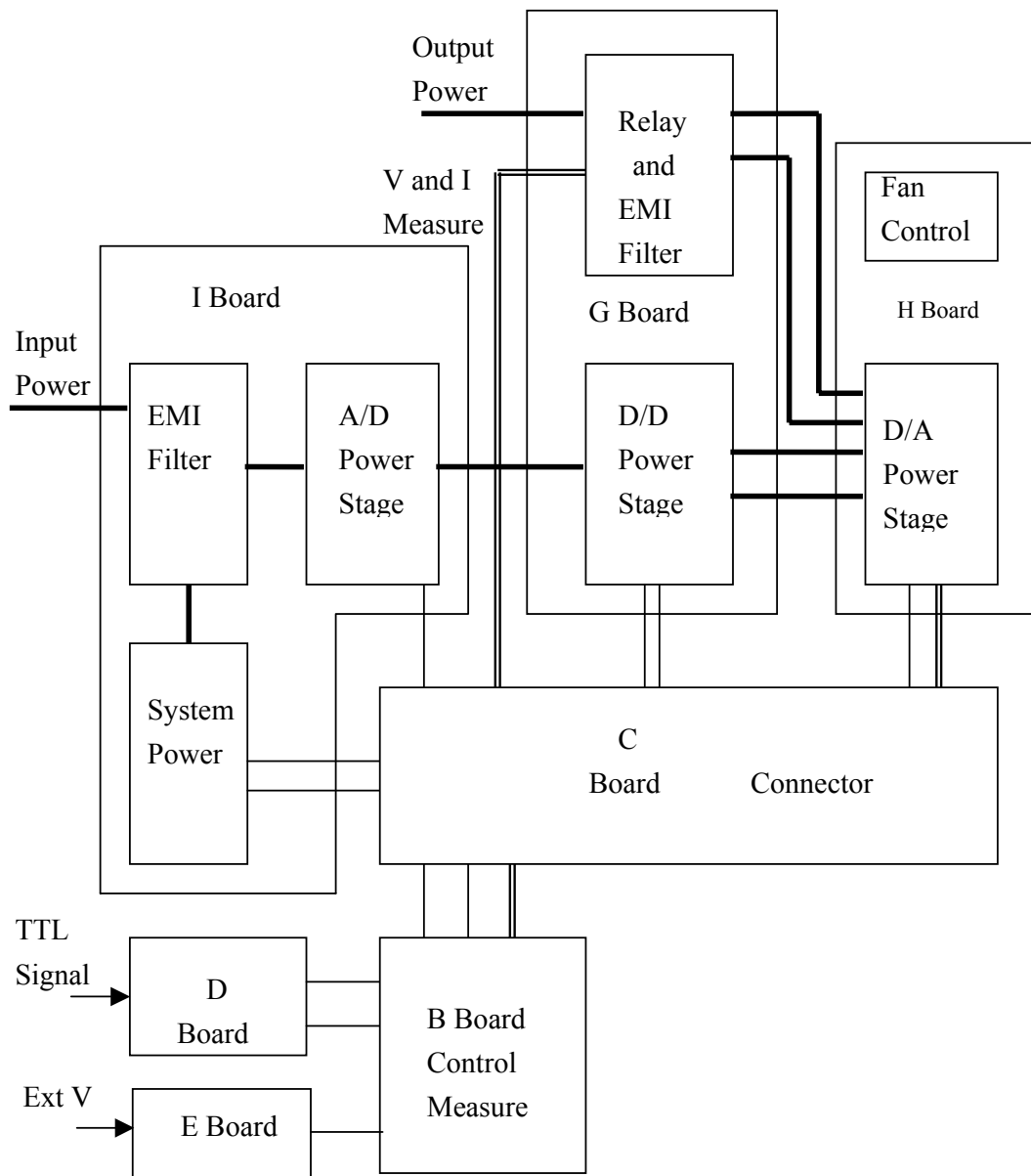


Figure 5.2.1 The Structure of Power Transfer Unit

6. Self-test and Troubleshooting

6.1 General

This section describes the self-test steps and suggested troubleshooting procedures when AC source does not function normally. If the problem cannot be solved using the information given here, consult the distributor whom you purchased the unit.

6.2 Self-test

When power-on the AC source, it performs a series of self-test. Firstly, it does the memory, data and communication self-test. They contain three items: DISPLAY, WAVEFORM, and REMOTE. If any failure is detected on a certain item, an "error code" will be shown at the right side of that item. The following table shows all the error messages:

Error Code	Description	Remark
Bit 0	SRAM error	0 – OK, 1 - ERROR
Bit 1	CODE error	0 – OK, 1 – ERROR
Bit 2	DATA error	0 – OK, 1 – ERROR
Bit 3	Communication error	0 – OK, 1 - ERROR
Bit 4	Output test result	0 – OK, 1 – ERROR
Bit 5	Reserved	
Bit 6	Reserved	
Bit 7	Reserved	

Example : If error code shows " ERROR = 05 ", the error code in binary is " 00000101".

The bit 0 and bit 2 are " 1 ". So " ERROR = 05 " means SRAM error and DATA error occurs.

Error Message	Description	Action
SRAM error	SRAM test fail.	Consult your dealer for assistance.
CODE error	Program code test fail.	Consult your dealer for assistance.
DATA error	Data in Flash or EEPROM test fail.	Consult your dealer for assistance.
Communication error	Cannot communicate.	1. Power off the AC source, wait for three seconds, power on again. 2. Consult your dealer for assistance.

After the memory, data and communication self-test, the AC source does the power output self-test. In this procedure, the output relays are in OFF state to sure not harming the load connecting on output terminal. Then, the AC source will check if there is any protection signal sent from hardware. If it does, the display shows "Output self test <NG>". It means the AC source is abnormal. Press **ENTER** to see what protection condition is. If no protection signal, the AC source will program 300Vac and measure the voltage. If the measured voltage is over 300V±5V, the power self-test is failed, and the display also shows " Output self test <NG> ". Probably AC source has not been calibrated (updated the software especially). Users can do following steps to reassure.

1. Press **ENTER** to ignore the NG.
2. If no PROTECTION, press **PAGE/EXIT** to change to MAIN PAGE.
3. Program a small voltage as 10Vac then press **OUT/QUIT**, see the measurement from LCD display if V is about 10V or not.

If the reading of V is about 10V, the AC source needs to calibrate (see Chapter 4). If the reading does not change apparently or show an unreasonable value, or display shows PROTECTION, the AC source does have some problems. Consult your dealer for assistance.

6.3 Troubleshooting

The following table lists the operating problems and suggests corrective actions:

Problem	Reason	Solution
Poor measurement of V, I.	Aging of components result in deviation of characteristics.	Periodic calibration is required. Refer to Chap 4. Calibration.
Distorted output	1. The AC source output voltage is too low. 2. The rectified load is too large at high frequency.	1. Program higher output voltage. 2. Reduce the load or lower than the output frequency.
OVER TEMP protection (OTP)	1. Ambient temperature is too high. 2. Air way is obstructed.	1. Operate the unit 0 ~ 40°C 2. Unblock the air way.
OVER POWER protection (OPP)	The output power is over specification.	Remove the over power or lower down output voltage.
OVER CURRENT protection (OCP)	The output current is over specification or I LIMIT.	Remove the overload or relax the I LIMIT.
OUTPUT SHORT protection	1. The output is shorted. 2. External current reverse.	1. Remove the short. 2. Remove the load.
INPUT FAIL protection (UVP)	The AC source line input voltage is too low or too high.	Measure input voltage, and regulate it if it's over specification.

INT _ AD protection	1.Line input voltage cycle dropout. 2.Instant over current of output. 3. AD power stage damaged.	1.Check the stability of input voltage. 2.Remove the load. 3.If cannot reset the status of protection, consult the dealer for assistance.
INT _ DD protection	1.Line input voltage cycle dropout. 2.Instant over current of output. 3.DD power stage damaged.	1.Check the stability of input voltage. 2.Remove the load. 3.If cannot reset the status of protection, consult the dealer for assistance.
OUTPUT OVP protection	1.Remote sense is open. 2.Output voltage peak is over range.	1.Connect the output to remote sense terminals. 2.Check the settings of Vac and Vdc on MAIN PAGE.
Cannot control AC source by GPIB	1. The AC source unit address is incorrect. 2. GPIB cable is loose at rear.	1. Update address. 2. Check connection, tighten the screws.

7. Remote Operation

7.1 General Information

The AC source can be controlled remotely through the GPIB or the RS-232C port. The GPIB port is mostly used, but the RS-232C port is helpful too.

Technically speaking, the GPIB interface is quite different from the RS-232C interface. The GPIB interface is an 8-bit parallel data bus owning a host of bus commands for synchronization, and up to one Megabyte transfer rate. The RS-232C interface, a series bus with a few handshake lines for synchronization, is less capable, so its requirement is not so much, and the user can write a simple program to do basic remote control easily.

7.1.1 Setting the GPIB Address and RS-232C Parameters

The AC source is shipped with the GPIB address which is set at 30. The address can be only changed from the “CONF” functional list menu (please refer to 3.6.3). This menu is also used to select the RS-232C interface, and specify the parameters of RS-232C such as baud rate and parity.

7.1.2 Wire Connection of RS-232C

The AC source is shipped with the baud rate which is set at 19200, and with parity which is set as None. For RS-232C interface, only the signals of TxD and RxD are used for its transfer of data. The RS-232C connector is a 9-pin D subminiature female connector. The following table describes the pins and signals of RS-232C connector.

Pin No.	Input/Output	Description
1	---	No connection
2	OUTPUT	TxD
3	INPUT	RxD
4	---	No connection
5	---	GND
6	---	No connection
7	---	No connection
8	---	No connection
9	---	No connection

Interconnection between the computer (compatible with IBM PC) and the AC source is illustrated below:

PIN	IBM PC	AC Source
1	DCD	No Connection
2	RX	← TX
3	TX	→ RX
4	DTR	No Connection
5	GND	—— GND
6	DSR	No Connection
7	RTS	No Connection
8	CTS	No Connection
9	RI	No Connection

7.2 The GPIB Capability of the AC Source

GPIB Capability	Description	Interface Functions
Talker/Listener	Commands and response messages can be sent and received over the GPIB bus. Status information can be read using a series poll.	AH1, SH1, T6, L4
Service Request	The AC source sets the SRQ line true if there is an enabled service request condition.	SR1
Remote/Local	The AC source powers up in local state. In local state, the front panel is operative, and the AC source responds to the commands from GPIB. In remote state*, all front panel keys except the "<PAGE/EXIT>" key are disabled. Press "<PAGE/EXIT>" key to return the AC source to local state.	RL1

*Remote State:

The panel shows remote message on the LCD display as below:

Vac = 0.0_				R H
Freq = 60.00		Pt = 0.0		
Vrms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00	▲
I rms	Φ1 = 0.00	Φ2 = 0.00	Φ3 = 0.00	▼

In remote state, all front panel keys except the “<PAGE/EXIT>” key are disabled. Press the “<PAGE/EXIT>” key to return the AC source to the local state.

7.3 Introduction to Programming

All commands and response messages are transferred in form of ASCII codes. The response messages must be read completely before a new command is sent, otherwise the remaining response messages will be lost, and a query interrupt error will occur.

7.3.1 Conventions

Angle brackets	< >	Items in angle brackets are parameter abbreviations.
Vertical bar		Vertical bar separates alternative parameters.
Square brackets	[]	Items in square brackets are optional. For example, OUTP [: STATE] means that : STATE may be omitted.
Braces	{ }	Braces indicate the parameters that may be repeated. The notation <A> {<, B>} means that parameter “A” must be entered while parameter “B” may be omitted or entered once or more times.

7.3.2 Numerical Data Formats

All data programmed to or returned from the AC source are ASCII. The data can be numerical or character string.

Numerical Data Formats

Symbol	Description	Example
NR1	It is a digit with no decimal point. The decimal is assumed to be at the right of the least significant digit.	123, 0123
NR2	It is a digit with a decimal point.	12.3, .123
NR3	It is a digit with a decimal point and an exponent.	1.23E+2

7.3.3 Boolean Data Format

The Boolean parameter <Boolean> takes only the form ON|OFF.

7.3.4 Character Data Format

The character strings returned by query command may take either of the following forms:

- <CRD> Character Response Data: character string with maximum length of 12.
- <SRD> String Response Data: character string.

7.3.5 Basic Definition

Command Tree Table:

The commands of the AC source are based on a hierarchical structure, also known as a tree system. In order to obtain a particular command, the full path to that command must be specified. This path is represented in the table by placing the highest node in the farthest left position of the hierarchy. Lower nodes in the hierarchy are indented in the position to the right, below the parent node.

Program Headers:

Program headers are key words that identify the command. They follow the syntax described in subsection 7.6 of IEEE 488.2. The AC source accepts characters in both upper and lower case without distinguishing the difference. Program headers consist of two distinctive types, common command headers and instrument-controlled headers.

Common Command and Query Headers:

The syntax of common command and query headers is described in IEEE 488.2. It is used together with the IEEE 488.2-defined common commands and queries. The commands with a leading “*” are common commands.

Instrument-Controlled Headers:

Instrument-controlled headers are used for all other instrument commands. Each of them has a long form and a short form. The AC source only accepts the exact short and long forms. A special notation will be taken to differentiate the short form header from the long one of the same header in this subsection. The short forms of the headers are shown in characters of upper case, whereas the rest of the headers are shown in those of lower case.

Program Header Separator (:):

If a command has more than one header, the user must separate them with a colon (FETC:CURREN?, VOLT:DC 10). Data must be separated from program header by one space at least.

Program Message:

Program message consists of a sequence of zero or more elements of program message unit

that is separated by separator elements of program message unit.

Program Message Unit:

Program message unit represents a single command, programming data, or query.

Example : `FREQ?, OUTPut ON.`

Program Message Unit Separator (;):

The separator (semicolon ;) separates the program message unit elements from one another in a program message.

Example : `VOLT:AC 110 ; FREQ 120<PMT>`

Program Message Terminator (<PMT>):

A program message terminator represents the end of a program message. Three permitted terminators are:

- (1) <END> : end or identify (EOI)
- (2) <NL> : new line which is a single ASCII-encoded byte 0A (10 decimals).
- (3) <NL> <END> : new line with EOI.

Note: The response message is terminated by <NL> <END> for GPIB, and <NL> for RS-232C.

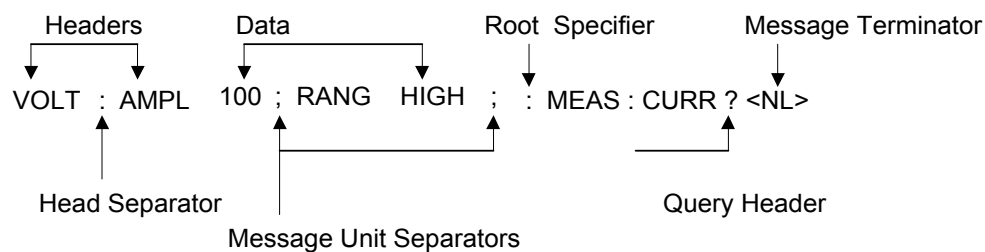


Figure 7-1 The Structure of Command Message

7.4 Traversal of the Command Tree

Multiple program message unit elements can be sent in a program message. The first command is always referred to the root node. Subsequent commands are referred to the same tree level as the previous command in a program message. A colon preceding a

program message unit changes the header path to the root level.

Example :

OUTPut : PROTection : CLear	All colons are header separators.
: OUTPut : PROTection : CLear	Only the first colon is a specific root.
OUTPut : PROTection : CLear; : VOLT : AC 100	Only the third colon is a specific root.

7.5 Execution Order

The AC source executes program messages by the order received. Program message units except coupled commands are executed in order of reception. The execution of coupled commands is deferred until program message terminator is received. A coupled command sets parameters which are affected by the setting of other commands. Problems may arise, because the prior state of the AC source will affect the response of a coupled parameter to its programming.

For example, assume that the current output voltage range is LOW, a new state is desired with output voltage range HIGH, and amplify 220 Volt. If the commands

```
VOLTage : AC      220<PMT>
VOLTage : RANGE  HIGH<PMT>
```

are sent, data out of range error will be produced. Reversing the order, or sending the commands in one program message can avoid such kind of error. For the above example, the program message

```
VOLTage : AC 220 ; VOLTage : RANGE HIGH<PMT>
```

can be sent without error.

7.6 The Commands of the AC Source

This subsection is going to talk about the syntax and parameters for all commands of the AC source. The examples given for each command are generic.

Syntax Forms	Definitions of syntax are in long form headers, whereas only short form headers appear in examples.
Parameters	Most commands require a parameter.
Return Parameters	All queries return a parameter.

Models If a command is merely applied to specific models, these models will be listed in the Model only entry. If there is no Model only entry, the command will be applied to all models.

7.6.1 Common Command Dictionary

Common commands begin with a “ * ”, and consist of three letters and/or one “ ? ” (query). Common commands and queries are listed alphabetically.

***CLS** Clear status

This command clears the following registers

- (1) Questionable Status Event
- (2) Status Byte
- (3) Error Queue

***ESE<n>** Standard event status enabled

This command programs the Standard Event register bits. If one or more of the enabled events of the Standard Event register is set, the ESB of Status Byte Register is set too.

Bit Configuration of Standard Event Status Enabled Register

Bit Position	7	6	5	4	3	2	1	0
Bit Name	PON	- - -	CME	EXE	DDE	QYE	- - -	OPC
CME = Command error				DDE = Device-dependent error				
EXE = Execution error				OPC = Operation complete				
PON = Power-on				QYE = Query error				

***ESE?** Return standard event status enabled

The query reads the Standard Event Status Event register. Reading of the register clears it. The bits of configuration are the same as Standard Event Status Enabled Register.

***IDN?** Return the AC source identification string

Return Parameter Chroma ATE 61700,123456,1.00,1.01,1.02

Chroma ATE : Company name

61700 : Model name

123456 : Serial number

1.00, 1.01,1.02 : Firmware version of display, waveform and remote

***RCL<n>** Restore the values of the specific group which is previously stored in memory.

Parameter 1 - 3

***RST** This command resets the AC source to the initial states. It's better to wait about 3 second to send the next command.

***SAV<n>** Save the values into the specific group in memory.

Parameter 1 - 3

***SRE** This command sets conditions of the Service Request Enabled Register. If one or more of the enabled events of the Status Byte Register is set, the MSS and RQS of Status Byte Register are set too.

***SRE?** This query returns the Service Request Enabled Register.

***STB?** This query returns the Status Byte Register.

Bit configuration of Status Byte Register

Bit Position	7	6	5	4	3	2	1	0
Condition	--	MSS RQS	ESB	MAV	QUES	--	--	--

ESB = event status byte summary

QUES = questionable status summary

RQS = request for service

MSS = master status summary

MAV = message available

***TST?** This command queries the self-test result of the AC source.

7.6.2 Instrument Command Dictionary

The commands are listed in alphabetical order. Commands followed by question marks (?) take only the query forms. When commands take both the command and query forms, they are noted in the query syntax descriptions.

7.6.2.1 SYSTEM Sub-system

SYSTem

: ERRor?

: VERSion?

: LOCal

: REMote

SYSTem : ERRor?

Description	: This command queries the error string of the command parser.
Query Syntax	: SYSTem : ERRor?
Parameters	: NONE
Return Parameters	: Response error string: No Error Data Format Error Data Range Error Too Many Errors Execution Error

SYSTem : VERSion?

Description	: This query requests the AC source to identify itself.
Query Syntax	: SYSTem : VERSion?
Parameters	: NONE
Return Parameters	:

SYSTem : LOCAL

Description	: This command can only be used under the control of RS-232C. If SYST: LOC is programmed, the AC source will be set in the LOCAL state, and the front panel will work.
Query Syntax	: NONE
Parameters	: NONE
Return Parameters	: NONE

SYSTem : REMote

Description	: This command can only be used under the control of RS-232C. If SYST: REM is programmed, the AC source will be set in the REMOTE state, and the front panel will be disabled except the "<PAGE/EXIT> key.
Query Syntax	: NONE
Parameters	: NONE
Return Parameters	: NONE

7.6.2.2 INSTRUMENT Sub-system**INSTrument**

: COUPle
: NSELect
: SELect

INSTrument : COUPle

Description	: In a multi-phase power source it is convenient to set parameters for all phases simultaneously with one
-------------	---

programmed command. When INST: COUP ALL command is programmed, a command will be sent to the AC source, and to all phases in the end. INST: COUP NONE command cancels COUP ALL command. This command affects the set voltage only.

Query Syntax : INSTRUMENT : COUPle?
Parameters : ALL | NONE
Return Parameters : NONE

INSTRUMENT : NSElect

Description : This command sets individual outputs in a multi-phase model for subsequent commands or queries. If INST: COUP NONE is programmed, the phase-selective commands are sent to the particular output phase set by INSTRUMENT: NSElect. If INST: COUP ALL is programmed, Remote Operation all commands are sent to all output phases. This command affects the set voltage and queries measurement data. For example, if "INST: COUP ALL", "INST : NSEL 2" and "Meas : V?" are programmed, the AC source will return Φ 2's measured voltage. INST: NSEL selects phase by number.

Query Syntax : INSTRUMENT : NSElect?
Parameters : 1 | 2 | 3
Return Parameters : 1 | 2 | 3

INSTRUMENT : SElect

Description : This command sets individual outputs in a multi-phase model for subsequent commands or queries. If INST: COUP NONE is programmed, the phase-selective commands are sent to the particular output phase set by INSTRUMENT: SElect. If INST: COUP ALL is programmed, Remote Operation all commands are sent to all output phases. This command affects the set voltage and queries measurement data. For example, if "INST: COUP ALL", "INST: SEL OUTPUT2" and "Meas: V?" are programmed, the AC source will return Φ 2's measured voltage. INST: SElect selects phase by name.

Query Syntax : NONE
Parameters : OUTPUT1 | OUTPUT2 | OUTPUT3
Return Parameters : NONE

INSTRUMENT : PHASe : SLAVE1

Description : This command sets the phase shift between Φ 1 and Φ 2. The default value is 120 degree.

Query Syntax : INSTRUMENT : PHASe : SLAVE1?
Parameters : <NR1>, valid range: 0 ~ 359.9
Return Parameters : <NR1>

INSTRument : PHASe : SLAVE2

Description	: This command sets the phase shift between $\Phi 1$ and $\Phi 3$. The default value is 240 degree.
Query Syntax	: INSTRument : PHASe : SLAVE2?
Parameters	: <NR1>, valid range: 0 ~ 359.9
Return Parameters	: <NR1>

7.6.2.3 FETCH & MEASURE Sub-system**FETCh | MEASure**

[: SCALar]	
: CURRent	
: AC?	Query the rms current
: DC?	Query the DC current level
: AMPLitude : MAXimum?	Query the peak current
: CRESTfactor?	Query the current crest factor
: INRush?	Query the inrush current
: FREQuency?	Query the frequency
: POWer	
: AC	
: [: REAL]?	Query the true power
: APParent?	Query the apparent power
: REACTive?	Query the reactive power
: PFACtor?	Query the power factor
: TOTal?	Query the total power
: VOLTag	
: ACDC?	Query the rms voltage
: DC?	Query the DC voltage

This command lets the user get measurement data from the AC source. Two measurement commands are available: MEASure and FETCh. MEASure triggers the acquisition of new data before returning data. FETCh returns the previously acquired data from measurement buffer.

FETCh [: SCALar] : CURRent : AC?**MEASure [: SCALar] : CURRent : AC?**

Description	: These queries return the rms current which is being output at the output terminal.
Query Syntax	: FETCh : CURRent : AC?, MEASure : CURRent : AC?
Return Parameters	: <NR2>

FETCh [: SCALar] : CURRent : DC?**MEASure [: SCALar] : CURRent : DC?**

Description : These queries return the DC current which is being output at the output terminal.
 Query Syntax : FETCh : CURRent : DC?, MEASure : CURRent : DC?
 Return Parameters : <NR2>

FETCh [: SCALar] : CURRent : AMPLitude : MAXimum?

MEASure [: SCALar] : CURRent : AMPLitude : MAXimum?

Description : These queries return the absolute value of peak current.
 Query Syntax : FETCh : CURRent : AMPLitude : MAXimum?,
 MEASure : CURRent : AMPLitude : MAXimum?
 Return Parameters : <NR2>

FETCh [: SCALar] : CURRent : CRESfactor?

MEASure [: SCALar] : CURRent : CRESfactor?

Description : These queries return the output current crest factor. It is the ratio of peak output current to rms output current.
 Query Syntax : FETCh : CURRent : CRESfactor?
 MEASure : CURRent : CRESfactor?
 Return Parameters : <NR2>

FETCh [: SCALar] : CURRent : INRush?

MEASure [: SCALar] : CURRent : INRush?

Description : These queries return the inrush current which is being output at the output terminal.
 Query Syntax : FETCh:CURRent: INRush?, MEASure: CURRent : INRush?
 Return Parameters : <NR2>

FETCh [: SCALar] : FREQuency?

MEASure [: SCALar] : FREQuency?

Description : These queries return the output frequency in Hertz.
 Query Syntax : FETCh : FREQuency?
 MEASure : FREQuency?
 Return Parameters : <NR2>

FETCh [: SCALar] : POWer : AC [: REAL] ?

MEASure [: SCALar] : POWer : AC [: REAL] ?

Description : These queries return the true power which is being output at output terminals in watts.
 Query Syntax : FETCh : POWer : AC?
 MEASure : POWer : AC?
 Return Parameters : <NR2>

FETCh [: SCALar] : POWer : AC : APParent?

MEASure [: SCALar] : POWer : AC : APParent?

Description : These queries return the apparent power which is being output at output terminals in volt-amperes.
 Query Syntax : FETCh : POWer : AC : APParent?
 MEASure : POWer : AC : APParent?
 Return Parameters : <NR2>

FETCh [: SCALar] : POWer : AC : REACtive?**MEASure [: SCALar] : POWer : AC : REACtive?**

Description : These queries return the reactive power which is being output at output terminals in volt-amperes. Reactive power is computed as: VAR

$$= \sqrt{APPARENTPOWER^2 - REALPOWER^2}$$

Query Syntax : FETCh : POWer : AC : REACtive?
MEASure : POWer : AC : REACtive?

Return Parameters : <NR2>

FETCh [: SCALar] : POWer : AC : PFACtor?**MEASure [: SCALar] : POWer : AC : PFACtor?**

Description : These queries return the power factor which is being output at output terminals. Power factor is computed as:

$$PF = TRUE\ POWER / APPARENT\ POWER$$

Query Syntax : FETCh : POWer : AC : PFACtor?
MEASure : POWer : AC : PFACtor?

Return Parameters : <NR2>

FETCh [: SCALar] : POWer : AC : TOTAl ?**MEASure [: SCALar] : POWer : TOTAl ?**

Description : These queries return the total true power which is being output at 3-phase of output terminals in watts.

Query Syntax : FETCh : POWer : AC : TOTAl?
MEASure : POWer : AC : TOTAl?

Return Parameters : <NR2>

FETCh [: SCALar] : VOLTage : ACDC?**MEASure [: SCALar] : VOLTage : ACDC?**

Description : These queries return the rms voltage which is being output at the output terminals.

Query Syntax : FETCh [: SCALar] : VOLTage : ACDC?
MEASure [: SCALar] : VOLTage : ACDC?

Return Parameters : <NR2>

FETCh [: SCALar] : VOLTage : DC?**MEASure [: SCALar] : VOLTage : DC?**

Description : These queries return the DC composition of output voltage which is being output at the output terminals.

Query Syntax : FETCh [: SCALar] : VOLTage : DC?
MEASure [: SCALar] : VOLTage : DC?

Return Parameters : <NR2>

7.6.2.4 OUTPUT Sub-system**OUTPut**

[: STATe]

: RELay
 : SLEW
 : VOLTage
 : AC
 : DC
 : PROTection
 : CLear

OUTPut [: STATe]

Description : This command enables or disables the output of the AC source. Disable output is to set an output voltage amplitude at 0 Volt.
 Query Syntax : OUTPut [: STATe]?
 Parameters : OFF | ON
 Return Parameters : OFF | ON

OUTPut : RELay

Description : This command sets output relay on or off.
 Query Syntax : OUTPut : RELay?
 Parameters : OFF | ON, ON sets the output relay of the AC source on (closed). OFF sets the output relay of the AC source off (open).
 Return Parameters : OFF | ON

OUTPut : SLEW : VOLTage : AC

Description : This command sets the slew rate of the AC output voltage.
 Query Syntax : OUTPut : SLEW : VOLTage : AC?
 Parameters : <NR2>, valid range: 0.000V/ms ~ 1200.000V/ms
 Return Parameters : <NR2>

OUTPut : SLEW : VOLTage : DC

Description : This command sets the slew rate of the DC composition voltage.
 Query Syntax : OUTPut : SLEW : VOLTage : DC?
 Parameters : <NR2>, valid range: 0.000V/ms ~ 1000.000V/ms
 Return Parameters : <NR2>

OUTPut : PROTection : CLear

Description : This command clears the latch that disables the output when an overcurrent (OC), overtemperature (OT), overpower (OP) or remote inhibit (RI) is detected. All conditions, which have generated the fault, must be removed before the latch is cleared.
 Query Syntax : None
 Parameters : None
 Return Parameters : None

7.6.2.5 SOURCE Sub-system

[SOURce :]

CURRent
 : LIMit
 : DELay
 : INRush
 : STARt
 : INTerval
 FREQency
 [: {CW | IMMEDIATE}]
 VOLTage
 [: LEVel][: IMMEDIATE][: AMPLitude]
 : AC
 : DC
 : LIMit
 : AC
 : DC
 : PLUS
 : MINus
 : RANGE

[SOURce :] CURRent : LIMit

Description	: This command sets the rms current limit of the AC source for software protection.
Query Syntax	: [SOURce :] CURRent : LIMit?
Parameters	: <NR2>, valid range: 0.00 ~ maximum current spec. of the specific model. (unit: A)
Return Parameters	: <NR2>

[SOURce :] CURRent : DELay

Description	: This command sets the delay time for triggering over current protection.
Query Syntax	: [SOURce :] CURRent : DELay?
Parameters	: <NR2>, valid range: 0.0 ~ 5.0 (unit: 0.5 second)
Return Parameters	: <NR2>

[SOURce :] CURRent : INRUsh : STARt

Description	: This command sets the start time of the inrush current measurement.
Query Syntax	: [SOURce :] CURRent : INRUsh : STARt?
Parameters	: <NR2>, valid range: 0.0 ~ 999.9 (unit: ms)
Return Parameters	: <NR2>

[SOURCE :] CURRent : INRUsh : INTerval

Description : This command sets the measuring interval of the inrush current measurement.

Query Syntax : [SOURCE :] CURRent : INRUsh : INTerval?

Parameters : <NR2>, valid range: 0.0 ~ 999.9 (unit: ms)

Return Parameters : <NR2>

[SOURCE :] FREQuency [: {CW | IMMEDIATE}]

Description : The command sets the frequency of the output waveform of the AC source in Hz.

Query Syntax : [SOURCE :] FREQuency [: {CW | IMMEDIATE}]?

Parameters : <NR2>, valid range: 15.00 ~ 1200.00 (unit: Hz)

Return Parameters : <NR2>

[SOURCE :] VOLTage [: LEVel][: IMMEDIATE][: AMPLitude] : AC

Description : This command sets the AC composition of output voltage in Volts.

Query Syntax : [SOURCE :] VOLTage [: LEVel][: IMMEDIATE][: AMPLitude] : AC?

Parameters : <NR2>, valid range: 0.0 ~ 150.0 (in low range), 0.0 ~ 300.0 (in high range)

Return Parameters : <NR2>

[SOURCE :] VOLTage [: LEVel][: IMMEDIATE][: AMPLitude] : DC

Description : This command sets the DC composition of output voltage in Volts.

Query Syntax : [SOURCE :] VOLTage [: LEVel][: IMMEDIATE][: AMPLitude] : DC?

Parameters : <NR2>, valid range: -212.1 ~ 212.1 (in low range), -424.2 ~ 424.2 (in high range)

Return Parameters : <NR2>

[SOURCE :] VOLTage : LIMit : AC

Description : This command sets the setting of Vac LIMIT which will restrict the value of Vac.

Query Syntax : [SOURCE :] VOLTage : LIMit : AC?

Parameters : <NR2>, valid range: 0.0 ~ 300.0 (unit: V)

Return Parameters : <NR2>

[SOURCE :] VOLTage : LIMit : DC : PLUS

Description : This command sets the setting of Vdc LIMIT(+) which will restrict the value of Vdc.

Query Syntax : [SOURCE :] VOLTage : LIMit : DC : PLUS?

Parameters : <NR2>, valid range: 0.0 ~ 424.2 (unit: V)

Return Parameters : <NR2>

[SOURCE :] VOLTage : LIMit : DC : MINus

Description	: This command sets the setting of Vdc LIMIT(-) which will restrict the value of Vdc.
Query Syntax	: [SOURce :] VOLTage : LIMit : DC : MINus?
Parameters	: <NR2>, valid range: 0.0 ~ -424.2 (unit: V)
Return Parameters	: <NR2>

[SOURce :] VOLTage : RANGE

Description	: This command sets output voltage range with two options of LOW(150 V), HIGH(300 V).
Query Syntax	: [SOURce :] VOLTage : RANGE?
Parameters	: LOW HIGH
Return Parameters	: LOW HIGH

7.6.2.6 CONFIGURE Sub-system**[SOURce :]**

CONFigure
: INHibit
: EXTernal
: COUPling

[SOURce :] CONFigure : INHibit?

Description	: This command sets REMOTE INHIBIT state. There are three states for the feature of remote inhibit: OFF, LIVE, and TRIG.
Query Syntax	: [SOURce :] CONFigure : INHibit?
Parameters	: OFF LIVE TRIG
Return Parameters	: OFF LIVE TRIG

[SOURce :] CONFigure : EXTernal

Description	: This command enables or disables the external controlled analog signal input from external devices.
Query Syntax	: [SOURce :] CONFigure : EXTernal?
Parameters	: OFF ON
Return Parameters	: OFF ON

[SOURce :] CONFigure : COUPling?

Description	: This command sets the coupling mode to present AC source output from external V reference: AC_AMPLIFIER and DC_LEVEL_CTL.
Query Syntax	: [SOURce :] CONFigure : COUPling?
Parameters	: AC DC
Return Parameters	: AC DC

7.6.2.7 PHASE Sub-system

[SOURce :]

PHASe

: ON

: OFF

[SOURce :] PHASe : ON

Description : This command sets the transition angle of the waveform when it out. Default DEGREE ON is 0 degree.

Query Syntax : [SOURce :] PHASe : ON?

Parameters : <NR2>, valid range: 0.0 ~ 359.9

Return Parameters : <NR2>

[SOURce :] PHASe : OFF

Description : This command sets the transition angle of the waveform when it quit.

Query Syntax : [SOURce :] PHASe : OFF?

Parameters : <NR2>, valid range: 0.0 ~ 360.0, 360.0: mean is IMMED.

Return Parameters : <NR2>

7.6.2.8 STATUS Sub-system

STATus

: OPERation

[: EVENT]?

: ENABle

: QUEStionable

: CONDItion

: ENABle

: NTRansition

: PTRansition

STATus : OPERation [: EVENT]?

Description : This command queries the Operation Status register.

Query Syntax : STATus : OPERation [: EVENT]?

Parameters : None

Return Parameters : Always zero.

STATus : OPERation : ENABle

Description : This command sets the Operation Status Enable register. The register is a mask which enables specific bits from the Operation Status register.

Query Syntax : STATus : OPERation : ENABle?

Parameters : <NR1>, valid range: 0 ~ 255

Return Parameters : Always zero

STATus : QUEStionable : CONDition?

Description	: This query returns the value of the Questionable Condition register, which is a read-only register that holds the real-time questionable status of the AC source.
Query Syntax	: STATus : QUEStionable : CONDition?
Parameters	: NONE
Return Parameters	: <NR1>, valid range: 0 ~ 511

STATus : QUEStionable [: EVENT] ?

Description	: This query returns the value of the Questionable Event register. The Event register is a read-only register which holds all events that are passed by the Questionable NTR and/or PTR filter. If QUES bit of the Service Request Enabled register is set, and the Questionable Event register > 0, QUES bit of the Status Byte register is set too.
Query Syntax	: STATus : QUEStionable [: EVENT]?
Parameters	: NONE
Return Parameters	: <NR1>, valid range: 0 ~ 511

STATus : QUEStionable : ENABle

Description	: This command sets or reads the value of the Questionable Enable register. The register is a mask which enables specific bits from the Questionable Event register to set the questionable summary(QUES) bit of the Status Byte register.
Query Syntax	: STATus : QUEStionable : ENABle?
Parameters	: <NR1>, valid range: 0 ~ 65535
Return Parameters	: <NR1>

STATus : QUEStionable : NTRansition

Description	: These commands make the values of the Questionable NTR register set or read. These registers serve as polarity filters between the Questionable Enable and Questionable Event registers, and result in the following actions:
-------------	--

- * When a bit of the Questionable NTR register is set at 1, a 1-to-0 transition of the corresponding bit in the Questionable Condition register will cause that bit in the Questionable Event register to be set.
- * When a bit of the Questionable PTR register is set at 1, a 0-to-1 transition of the corresponding bit in the Questionable Condition register will cause that bit in the Questionable Event register to be set.
- * If the two same bits in both NTR and PTR registers are set at 0, no transition of that bit in the Questionable Condition register can set the corresponding bit in the Questionable Event register.

Bit Configuration of Questionable Status Register

Bit Position	15-9	8	7	6	5	4	3	2	1	0
Condition	---	OVP	INP	OCP	FAN	SHT	OTP	OPP	INT-DD	INT-AD

OVP : Output voltage protection
 INP : Line input protection.
 OCP : Over current protection.
 FAN : Fan failure.
 SHT : Output short protection.
 OTP : Over temperature protection.
 OPP : Over power protection.
 INT-DD : Inner DD power stage protection
 INT-AD : Inner AD power stage protection

Query Syntax : STATus : QUEStionable : NTRansition?
 Parameters : <NR1>, valid range: 0 ~ 65535
 Return Parameters : <NR1>

STATus : QUEStionable : PTRansition

Description : These commands make the values of the Questionable PTR register set or read. Please refer to the description of the previous command.
 Query Syntax : STATus : QUEStionable : PTRansition?
 Parameter : <NR1>, valid range: 0 ~ 511
 Return parameters : <NR1>

7.7 Command Summary

Common Commands

* CLS Clear status
 * ESE<n> Standard event status enable
 * ESE? Return standard event status enable
 * IDN? Return the AC source identification
 * RCL<n> Recall the AC source file
 * RST Reset the AC source to the initial states
 * SAV<n> Save the AC source status
 * SRE Set request enable register
 * STB? Return status byte
 * TST? Return the self-test result of the AC source

Instrument Commands

INSTrument

: COUPle

: NSElect
 : SElect
 : PHASe
 : SLAVE1
 : SLAVE2

FETCh | MEASure

[: SCALar]
 : CURRent
 : AC?
 : DC?
 : AMPLitude : MAXimum?
 : CRESTfactor?
 : INRush?
 : FREQuency?
 : POWer
 : AC
 [: REAL]?
 : APParent?
 : REACtive?
 : PFACtor?
 : TOTal?
 : VOLTage
 : ACDC?
 : DC?

OUTPut

[: STATE]
 : RELay
 : SLEW
 : VOLTage
 : AC
 : DC
 : PROTection
 : CLEar

[SOURce :]

CURRent
 : LIMit

- : DELay
- : INRush
 - : STARt
 - : INTerval
- FREQency
 - [: {CW | IMMEDIATE}]
- VOLTage
 - [: LEVel][: IMMEDIATE][: AMPLitude]
 - : AC
 - : DC
 - : LIMit
 - : AC
 - : DC
 - : PLUS
 - : MINus
- : RANGE

[SOURce :]

- PHASe
 - : ON
 - : OFF

[SOURce :]

- CONFigure
 - : INHibit
 - : EXTernal
 - : COUPling

STATus

- : OPERation
 - [: EVENT]?
 - : ENABle
- : QUEStionable
 - : CONDItion
 - : ENABle
 - : NTRansition
 - : PTRansition

Appendix A Pin Assignment of TTL SIGNAL

9-Pin D-Type Female Connector:

Pin No.	Signal	Pin No.	Signal
1	GND	6	GND
2	/ Remote-Inhibit	7	GND
3	GND	8	/ FAULT-OUT
4	AC-ON	9	---
5	---		

/ Remote-Inhibit: When voltage level of this pin becomes LOW, it can inhibit the output of AC source (See 3.6.1).

AC-ON: When AC source output voltage, this pin will become HIGH, and it becomes LOW when quit output.

/ FAULT-OUT: The voltage level of this pin is HIGH if AC source is in normal state. It becomes LOW when AC source is in protection state.